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The Outlook.

While times of adversity try men's souls, times of prosperity try their business intelligence. Looking back over the record of 1906 there seems little to be ashamed of. Manufacturing has been conducted on a greater scale than ever before, crops have been good and workmen have been more steadily employed. We have transacted a tidy bit of foreign business and have done something to help secure more later. Better than anything else, the people have kept their heads when a few dollars burned in their pockets, and instead of spending their money like drunken sailors they have put it in the banks or invested it sensibly. The only class that fared hard was that which tried to dispose of paper gold mines and such green goods. The money made in the Central and Western States has been used in the rational development of those sections, and competent critics who have studied conditions there say that the farmers have been showing remarkable ability in improving their lands and in taking precautions against bad seasons, something for which the Secretary of Agriculture deserves much of the credit. In the larger cities there has been some indication of improvidence and unrest by certain classes of labor, influenced by the yellow newspapers, but this condition is localized as yet. The past year has certainly been a good one, and the year ahead opens fair. In most industries there is a large volume of orders booked or in sight from responsible sources. There is no marked speculative building of any sort, and the only thing that seems to contain the germs of possible trouble is the projected competitive railway construction in the far Northwest. The country has developed so rapidly that the opportunities for investment in industries or transportation facilities to meet real demands are more attractive for the savings of people of moderate means than are the glittering fakes which have been unsuccessfully dangled before them. The small stockholder class has now become an influential factor in steadying popular opinion and in diminishing the influence of those who make a living by producing trouble between employer and employe. People generally recognize that steady work at fair wages is better than a few years of high wages and then a lean period with little to do, and there is very little complaint by skilled laborers that the unusual profits of last year's business are not properly used when invested in better facilities and resources to meet the next period of business depression. This sane foresight among workmen is a most gratifying omen of a happy new year.

The Ashokan Reservoir Stripping Report.

The influence of storage on the quality of a surface water supply was recognized in a general way years ago, but it was only within the last twenty years or so that the subject received careful study, except by a very few specialists, like the late Wm. Ripley Nichols and Alphonse Fteley. People may not have been so particular in 1875 as they are now about the tastes and odors in water supplies, or they may have been more complacent as to these defects in the absence of knowledge of practical remedies. Even to-day many instances of unsatisfactory quality in water for short periods at irregular intervals are probably unrecorded. With the growth of a demand for better water in many places, the problem of storage came to be recognized as an important factor in determining the quality of the supply reaching the consumer. It was studied in this country and abroad at many places, particularly in Massachusetts, and some valuable data were obtained which will long remain of direct practical value to designers of waterworks.

In the case of the large deep storage reservoirs of Great Britain, the summer temperatures of the water seldom exceed 65 deg. and are above 60 deg. for only short periods. This is probably the explanation of why the upper layers of water in the large British reservoirs have been so singularly free from objectionable growths of the blue-green algæ that have caused so much trouble in New England. British experience with troubles in stored waters has related mainly to the stagnation in the bottom layers of the basins. Incident to this stagnation have appeared tastes and odors due to the decomposition of organic matter, growths of fungi which caused marked reduction in carrying capacity of pipes and tunnels, and sufficient increases in free carbonic acid to affect lead pipes. These troubles furnish valuable information for a general study of the effect of storage, but they are not safe precedents as to midsummer complications from growths in American reservoirs. The latter relate essentially to complications in the top layers of water, while the troubles with bottom layers can be satisfactorily dealt with by filtration as in the instance of the new Welch supplies of Liverpool and Birmingham.

In the South and the Southwest the reservoirs are filled usually with water from streams containing large amounts of fine sediment which remains in suspension in the water for an almost indefinite period. This residual turbidity prevents the penetration of sunlight and the growth of algæ requiring sunlight; hence these reservoirs act quite like covered reservoirs and improvement rather than deterioration in the quality of water results from storage. In the case of those Southern supplies drawn from swampy areas, colored water has always to be contended with and in some cases the tastes and odors resulting from organic growths where seeding is inevitable. Prevention of such color and growths is obviously impractical on the ground of cost, and swampy waters in that section, like the turbid waters, have been successfully studied by engineers with a view to making them of satisfactory quality by filtration and otherwise.

In Massachusetts the conditions due to storage have probably attracted more attention than elsewhere. The supplies are generally upland surface water moderately or highly colored as a rule, and drawn from relatively small catchment basins. The Massachusetts storage problem became a serious one at a time when the available information concerning filtration was very limited, and there were strong doubts expressed concerning the extent of its usefulness. Intermittent sand filtration alone had any local standing at that time and was of very limited use in removing color, which was highly desirable in many cases. Under the existing local conditions it was decided for several projects in that section of the country that prevention was better than cure in the matter of tastes, odors and color in water, and that the right local treatment was to remove from the reservoir site all the soil containing appreciable amounts of organic matter, thus furnishing from the bottoms and sides of the basins no food material for organic growths; to minimize the original color of the impounded water by means of swamp drainage, and finally to bleach the water through the action of sunlight in impounding basins of a size much greater than that necessary to develop an economical yield of the watershed.

When the Board of Water Supply of New York City determined to build a great impounding reservoir in the Catskill Mountains, it placed on the shoulders of Mr. J. Waldo Smith, its chief engineer, the grave problem of deciding what could be best done to reduce to a minimum storage troubles as viewed by the consumer. Before these new works are in operation the people of New York City will doubtless be receiving water of a high quality in every respect from the filtration plant which is being designed for the Croton supply at Jerome Park Reservoir. Their criterion for estimating the character of the Catskill supply will therefore be a high one, and must be fully met. On the other hand, there was little information of direct use in reaching a decision as to the right way to reduce tastes and odors to a minimum. The water had less color and more clay turbidity than those of Massachusetts; it was wholly unlike the sediment-laden waters or highly colored surface water of the South and West, the reservoir capacity is enormous, and the temperature conditions at the Ashokan Reservoir are very different from those in Great Britain. Under the circumstances Mr. Smith followed the eminently wise course of submitting the problem to specialists, Messrs. Allen Hazen and George W. Fuller. An abstract of their report is printed elsewhere in this issue, and deserves very careful study. The recommendation to save the money that would be spent in stripping the reservoir site, in accordance with the practice at several places in Massachusetts, and to adopt aeration and filtration as a means of producing a uniformly good supply in all particulars, is based on such strong arguments that it is safe to say it will establish an important precedent in waterworks design.

Responsibility for Failure of Work Under Construction Due to Causes Beyond Contractor's Control.

It is one of the main purposes of a formal contract to provide as definitely as possible for all classes of responsibility that may arise from the execution of work. These responsibilities, as far as they can be clearly defined, are divided between the owner, usually represented by the engineer, and the contractor. Contracts are most unsatisfactory which do not make such provisions in full, but unfortunately much too large a percentage of them fail in this important particular, and lead to acute disputes and extended litigation before final settlements are reached. These sources of obscure obligations are of the kind which should be eliminated, especially as they are easily cured when the contract is properly drawn.

There is, on the other hand, a rather wide range of responsibilities not as well defined as could be desired, and which it is quite difficult to cover specifically in contracts, even when well prepared. Contracts in general provide that certain conditions shall be fulfilled by the owner, and it is perfectly obvious as a matter of law or of common sense that no contractor can be held responsible for the performance of his part of the work bearing upon such conditions, unless they are made good by the other party to the agreement.

It not infrequently happens that a contractor working efficiently and in good faith, completes a large part of his work precisely in the manner prescribed in the specifications, after which some portion, perhaps a large portion, of it fails in consequence of a high flood or other destructive effects of natural conditions over which neither he nor the owner have any control whatever. The owner has fully discharged his obligations under the contract, and the contractor has performed all parts of his work strictly in accordance with the specifications. Under such circumstances, obviously reference must be made to the provisions of the contract in order to determine the responsibility for the reconstruction of the failed work.

Contracts, especially lump sum contracts, are usually so drawn as to include general provisions requiring the contractor, in substance, if not in terms, to complete satisfactorily the entire work under their provisions, which rarely contain any terms specifically relieving him from the effects of what may be called destructive contingencies. A bridge company may, for instance, execute a contract to build a bridge across a river subject more or less to floods. The entire work of the superstructure may be satisfactorily prosecuted almost to the point of driving the last pin or bolting up the last joint when the falsework may be carried away by high water, and the nearly completed superstructure dropped into the river. Rarely, if ever, any question of responsibility for replacing the structure arises from such circumstances. The contractor simply replaces the destroyed spans and eventually delivers them complete and ready for use to the owner without additional compensation. It may, of course, be said that this particular hazard is more of the nature of an ordinary risk than some others, and therein lies an important consideration, viz., whether any distinction is to be made between risks of a more usual or ordinary character, and those which arise from causes more remote.

An earth embankment approach of a rather large bridge across a tidal stream was nearly completed in an entirely satisfactory manner with riprapped slopes. The bottom on which it rested was unusually stiff for such a location and had given no signs whatever of yielding, but without warning a part of the fill with the partially completed riprap slid completely out of place, making reconstruction necessary. It was probable in this particular instance that the presence of this embankment and the conditions attending its construction created new features of the situation involving seepage from an adjoining pond. The contract contained no provision covering such a development, it only required the contractor to complete the structure satisfactorily under conditions with which the owner had fully complied so far as he was affected by them. The influences or forces producing the failure were in no way whatever due to any act of the owner, nor did he fail to supply any known data. The contractor on his part complied with every provision of the specification, and his work was destroyed by forces over which he had no control.

These two specific instances are sufficient to illustrate this class of issues. Although occasionally contracts may be so explicit in some of their provisions as to remove any doubt of location of responsibility, they are usually much more general than that in character. It may reasonably be contended that where general provisions exist requiring the contractor to complete his work without specific exception of hazard, the responsibility of reconstruction rests upon him without relief. Just how far this principle may be applied where new attendant conditions of the work are created, or where as complete information as possible has not been supplied by the owner, may be open to question. On the other hand the contractor may incur serious obligation by creating new conditions incident to the operations of his force or in conducting some of his procedures of construction. At any rate any engineer experienced in the execution of contracts involving a considerable range of work, such as the building of complete bridges, both substructures and superstructures, large reservoirs and public works of magnitude, will easily realize how difficult it frequently becomes to limit definitely this field of a contractor's obligations. It is correspondingly important to cover explicitly, as far as possible, the respective responsibilities of contractor and owner in all such cases and thus eliminate to the greatest possible extent any obscurity as to contract obligations.

The Borings at Gatun.

The Gatun dam and lock site has been explored during the past year by 142 test holes and 32 were put down at the site of the proposed spillway, according to the annual report of the Isthmian Canal Commission. Owing to a manifestly erroneous statement in the report it is impossible to calculate the average depth of the 36 holes along the axis of the dam, but the maximum depth is definitely stated at 265 ft. Of the 108 holes put down at the site of the proposed locks, over half have been carried 60 ft. below sea level, a statement that may mean much or little. These borings are the most important thing, technically, that the commission has to show for its year's work, and it is unfortunate that their results are kept so strongly guarded from the public. This secrecy indicates to most people who have followed the irrational procedure of the President respecting this great work, that the physical conditions necessary for the execution of the 85-ft. project have proved so bad that the plan must be changed. The Engineering Record has nothing but admiration for that project, considered as a subject for study and discussion. Its very boldness almost takes away one's breath, not only on account of the great dike to be built on top of material which but few engineers would care to employ for the foundation of a millpond dam, but also because of the flight of locks surpassing anything previously undertaken. The project is certainly one of great interest, and has been discussed generally on the assumption that it was practicable. Very few people have been willing to admit without hesitation, however, that it is practicable, because, when it was drawn, there was no definite information about the real character of the site of the dam and locks. It is easy to see now that the project should not have been discussed after the manner of projects which an engineer will occasionally present to any engineering society in order to bring out the opinions of other experts concerning general features of technical work; the rational discussion it received from engineering critics probably deceived a great many people into believing it was a real working plan, rather than a mere project which might or might not prove practicable, according as the Gatun site, when explored, was found to be suitable or unsuitable for the great works projected there.

It will be interesting to see what course the President will follow in case the borings at the site of the proposed locks indicate that it is impossible to construct lock chambers long enough to handle safely vessels of the size it is reasonable to expect in the future. It is no secret that the administration of Panama canal affairs is to be one of the leading points of attack upon him and his party at the next national election campaign, and his course at the present time is therefore one of vital significance. Few engineers believe that it will be possible to construct at Gatun any works that will be large enough and safe enough to handle war vessels of the Dreadnought class or the great merchant ships which it seems reasonable to expect very soon. It is commonly believed that it will be necessary to shorten the locks, to use gates of problematical security, to locate the safety gates in such a place as to be useless when most needed, and to rely for the stability of the whole enormous group of works on very poor foundations. Congressmen and the people who are interested in public affairs are beginning to realize that a serious mistake was made in committing the country to this particular lock project and are asking why the President insisted so strongly on it to the exclusion of other and possibly more practicable lock route projects which could be so designed that the canal would have an ample capacity for all time and not become too small after ten or fifteen years' use, like the locks at Sault Ste. Marie. The significance of the fact that the 85-ft. project, once executed, cannot be changed is at last becoming a subject of serious reflection, and a good many comments are made in Washington that the President's course in jambing this project down the throat of Congress, before the extent of its practicability was determined in any way and while it was a mere paper plan, was a piece of illogical rashness that must be reconsidered carefully least the country commit a stupendous blunder. The fact that the whole affair is likely to become a national political issue is deplorable, but this is inevitable when anybody, overburdened with affairs of State, also assumes ability to pass judgment on engineering problems of the gravest character.

Alexander Johnston Cassatt.

The sudden death on Dec. 28 of A. J. Cassatt deprived the country of the man who shared with J. J. Hill the highest rank in railway circles. There are plenty of detractors of the work of both these leaders, but the fact remains that each of them directed roads of acknowledged preeminence as the best practical training schools for railway officials. The fields of the two were radically different, however, for one has given a model for the construction of pioneer roads, while the lessons taught by the other are along the lines of development of facilities for a closely peopled territory. Mr. Cassatt's problem was to take a railway in a chronic state of congested traffic, with inadequate seaboard terminals, and put it into a condition of efficiency for present needs and of preparation for future requirements. It is most sad that he did not live to see the execution of his plans, which will be completed in their main details within a couple of years, unless something now unforeseen happens. To develop and inaugurate them, he gave up the leisure and independence which his means permitted and his tastes preferred, and shouldered a tremendous burden out of nothing but love for good work well done. The presidency of the Pennsylvania Railroad Co., when he assumed it, was nothing to him but a great honor from men whose esteem he warmly appreciated. The presidency of no other railway company would have been attractive to him; that of the road with which he had been connected until his retirement was attractive because it meant the resumption of responsibilities with men he knew thoroughly and an opportunity to develop in this country a financially profitable railway having the same high-grade physical conditions as the leading British lines.

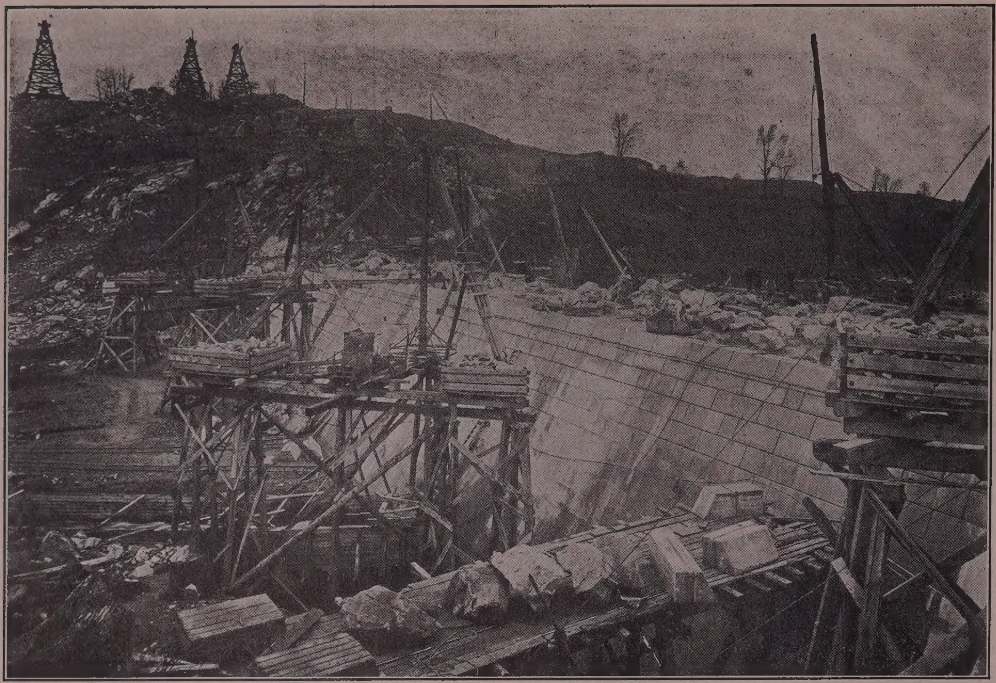
A great deal has been made of the alleged fact that Mr. Cassatt was primarily a civil engineer, as if his engineering knowledge were itself mainly the reason for his successful career. This is a wrong view to take. It has always been the Pennsylvania policy to fill places by promotion if possible, and it has also been its policy to make its construction and maintenance work of the highest practicable grade. On this account the company attracted to its civil engineering staff an unusually large proportion of young men of the best type. They were broad-gauge enough to know that the engineering staff spent money, and the place to begin railway training was consequently in that staff. They looked on it as many young men look on an engineering college course to-day, as something to be mastered for information but not as something to be used as a direct means of livelihood. After learning how and why money was spent in civil engineering work, most of these young men aspired for positions in the operating department, and their ability was of such high order that they obtained the desired appointments. Unquestionably the unusual engineering knowledge of the Pennsylvania officials has been responsible for some measure of their successful administration, but the main reason was their native executive ability, developed and encouraged by the men above them. Mr. Cassatt's career as an engineer proves this. The son of a wealthy Pittsburg banker, educated in Germany and the Rensselaer Polytechnic Institute, he began his work in 1859, when twenty years old, on a Georgia railway. Early in 1861 he resigned to become a rodman on the Pennsylvania R. R., two years later he was promoted to the grade of assistant engineer and in 1864 to that of resident engineer. Men who were in a position to estimate correctly the value of his services in those grades have always said that his success lay rather in getting the best work out of his associates than in any very unusual engineering knowledge of his own. With his appointment as superintendent of motive power his engineering duties became of a mechanical nature. It is well known that he never put much reliance on this part of his knowledge, and while his career at this post was satisfactory to the company he regarded it merely as a part of his education.

With his appointment as general superintendent of the line between Pittsburg and Philadelphia his career really began. He had a fair ballast of information concerning the way a company built and maintained its roadbed, structures and rolling stock; he possessed a fine physique and a strong constitution, such as are necessary for the men who handle great affairs; he had already demonstrated that he was a good leader and director of men under him. He was now given a chance to prove whether he could be anything more; whether he was able to win a fight against other well-equipped forces. That was the crucial test, and he very soon passed it successfully by absorbing the Camden & Amboy line in a most adroit manner. The stockholders of that company were fairly treated and the Pennsylvania terminal was shifted from the banks of the Delaware to the shores of the North River. It was a great achievement, and it was subsequent success in many things of a like nature that made him a great railway leader, not his engineering knowledge.

In the broadest sense, however, Mr. Cassatt showed great engineering judgment. The construction of the New York terminal, the plans just sanctioned by the city authorities for a freight line through Brooklyn and Queens to a connection with the New York, New Haven & Hartford R. R., the equivalent of an entirely new railway from Pittsburg to New York, the construction of belt lines around the leading cities, and the great improvement of grades characterize an administration of railway affairs based on a strong appreciation of the resources of advanced engineering practice. In all this work, the assistance of independent specialists was sought repeatedly, so that no road in the country represents better the composite judgment of acknowledged experts. There are defects, of course, which diligent search or accident may reveal, but on all these improvements made while Mr. Cassatt was president, the only weighty criticism has been their tremendous cost. Every man is willing to spend a dollar if he can get it back with fair interest, but as the amounts to be spent grow larger and larger, not even the certainty of profitable investment fails to prevent timidity in pretty bold men. Mr. Cassatt had none of this fear; it made no difference to him whether the investment was for a locomotive for experimental purposes or the greatest railway passenger terminal in the world, for so long as the investment was certain to pay and the money could be raised he would authorize it. There was a time after the trouble between the Pennsylvania R. R. and the Western Union Telegraph Co. when powerful influences previously antagonized in rebate controversies made his task a troublesome one, and people talked knowingly about the ill-advised recklessness of his great projects. There is very little gossip of this sort now. The completion of the tunnels under the North River have set at rest the crazy rumors of the impracticability of the scheme, while the recent decision of Mayor McClellan and his official family to approve the New York Connecting R. R. franchise on an equitable basis demonstrates that the great public importance of this project and the fairness of the company's proposals have at last won the favorable action they deserve.

The execution of his uncompleted work has been left in competent hands. The largest individual stockholder of the company, Mr. Frick, was thoroughly acquainted with Mr. Cassatt's ideas and has just been elected a director. Mr. McCrea, the new president, was in very close touch with the plans for operation and administration which were the basis of the late president's projects, while Mr. Rea's knowledge of the engineering problems of the company has been equal to that of his chief in broad outlines and far more thorough in details. It may be questioned if the company will be able for many years to secure another such president, but he did his work so well that the able men who assisted him can now carry it forward to a successful completion. His death deprives the company of its greatest officer and the public of a citizen whose career was a credit to the country and a model for its wealthy youths to emulate. But it does not mean that the Pennsylvania R. R. is left in hands unable to direct its policy with security for the stockholders and safety to the public.

THE COMPLETION OF THE BELMONT TUNNEL under the East River between Manhattan and Long Island City is a piece of work that Mr. St. John Clarke, the chief engineer, and the Degnon Contracting Co. have reason to be proud of. The engineering features of the tunnel were described in this journal on March 3, 1906. There are two parallel single-track tubes about 17,000 ft. in total length, driven from shafts on both sides of the river and at a reef in the channel. Shaft sinking was begun in July, 1904, and the work is now so far advanced that it is not improbable everything will be ready for cars on March 1, although the final touches may be delayed beyond that date. The tunnel will be used by the cars of the New York & Queens County R. R., which run through Long Island City, Flushing, Corona, Elmhurst and other places in the Borough of Queens. Less has been printed about this tunnel than any of the others which will connect Manhattan with Long Island, and the fact that tracks are now being laid in it will doubtless be a surprise to many readers.



Downstream Face of Dam and Derrick Towers

PROGRESS OF CONSTRUCTION ON THE CROSS RIVER DAM

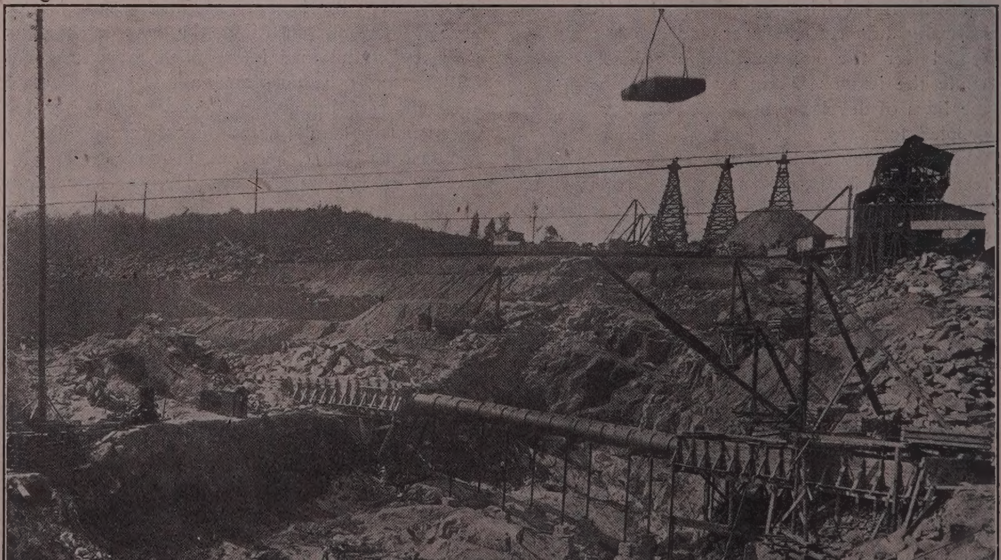
The Cross River dam under construction in the Croton watershed near Katonah, N. Y., is designed to impound about nine billion gallons of water for an additional supply to be delivered to the city of New York through the new Croton aqueduct. The reservoir will be three miles long and have a maximum depth of over 100 ft. The dam crosses the valley of the Cross River nearly at right angles to it, with a total length and height of about 900 ft. and 170 ft. respectively. The south end of the masonry dam terminates in an earth dam oblique to its axis, with a masonry core wall, and the north end terminates at a corresponding concrete overflow. The maximum cross-section is about 115 ft. wide at the base, above which both upstream and downstream faces are battered to a height of about 45 ft. Above this point the upstream face is vertical and the batter of the downstream face changes from 0.75 to 1, to 0.56 to 1, which continues to a point 50 ft. below the top, where it is tangent to a curve of 96 ft. radius tangent to the vertical under the coping, where the thickness of the dam is 23 ft. Its foundations are carried down to solid rock at a maximum distance of about 40 ft. below the original low-water level of the river. The structure is built of cyclopean masonry faced with concrete blocks of large dimensions corresponding to ashlar masonry. The principal quantities involved in its construction include about 117,000 cu. yd. of excavation and 155,000 cu. yd. of cyclopean and block masonry.

The importance of putting this reservoir in service at the earliest possible date, so as to hasten the availability of additional water supply in case of threatened water famine, was so urgent that its construction was deemed a work of emergency. The Aqueduct Commission in awarding this contract took into consideration not only the experience and ability for successfully conducting work of this character of the seven competing firms, but also the available plant controlled by each ready to be installed immediately on the work. In consideration of the large amount of suitable plant available and the skill and experience on this class of work, the contract was awarded to one of the highest bidders at a price of $1,246,211.60.

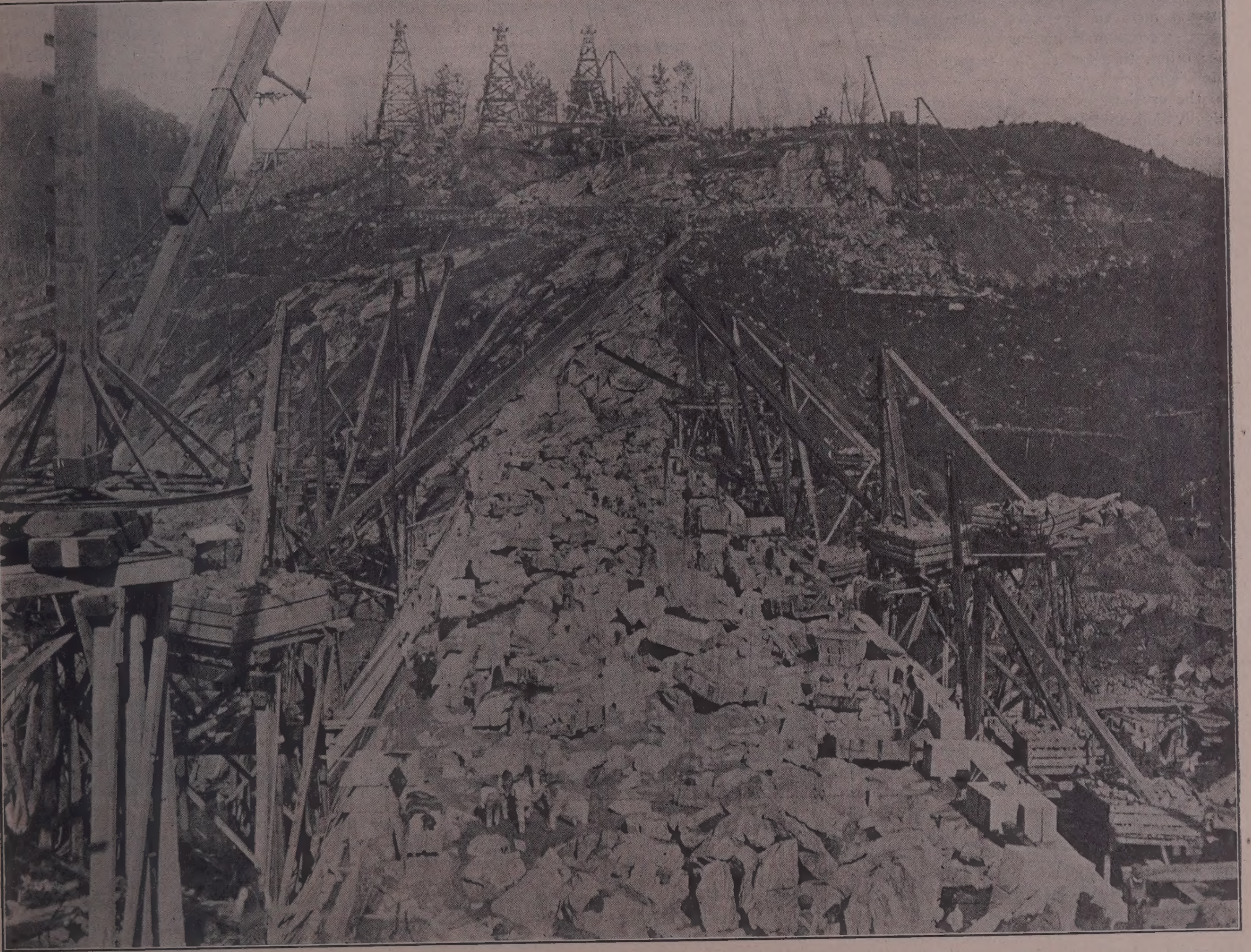
The contractors began operations in the latter part of June, 1905, and had hardly completed their organization when the work was practically shut down by a taxpayer's injunction. The injunction was removed late in November, 1905, and the contractors began at once to reorganize their force which had become dispersed during the shut-down. Work was begun with vigor and has continued since without interruption, days and considerable portion of the time, nights, during the past thirteen months. The details of the dam and the description of the construction plant were published in The Engineering Record of May 20, 1905, and June 16, 1906.

The contractors diverted the water from the site by means of two earth and rock-fill temporary dams across the valley above and below the permanent dam. These were connected by a wooden flume large enough to carry ordinary floods of the river over the excavation and were provided with two 5-ft. steel pipes 90 ft. long supported on steel columns across the axis of the dam. A standard gauge railroad track 1½ miles long was built to connect the dam site with the New York & Harlem R. R. tracks and provide for the delivery of plant and materials. The power plant, with about 1,000 h.-p. boiler capacity and air compressors rated at 1,120 h.-p., was established in the valley south of the dam, and on the hill near the south end of the dam there was also installed a machine and repair shop, a concrete mixing tower and plant, and a yard for casting the concrete blocks. A pumping plant was located on the river bank below the dam, and offices, storehouses, a commissary department and camps were provided for the men. Two quarries were opened, one near the dam on the down-stream side of the north end and the other upstream on the south side hill. One 18-ton cableway and two 15-ton cableways, all of about 1,300 ft. span, were installed parallel with the axis of the dam on movable towers enabling them to command the entire area of the work. Two additional cableways with fixed towers were temporarily installed at right angles to these and a number of derricks were erected to serve the concrete plant, the quarry and the excavation. The large and complicated plant installed has been supplemented by a very complete machine and repair shop which has proved able in many instances to afford immediate relief in cases of accidents, so that renewals have been made much more quickly than could have been accomplished if it had been necessary to send the machinery away for repairs. An illustration of this was afforded by the breaking of an important gear wheel in the large stone crusher. The fall line of one of the derricks broke and dropped its load on the crusher, throwing it out of commission. New parts were immediately ordered by telegraph, but without waiting for them to be received the master mechanic removed the broken wheel and succeeded in splicing the parts together with outside strips which enabled it to be returned to service, and the crusher was put in operation within 24 hours. The new parts were received several days later and have since remained in reserve, the mended piece still performing satisfactory duty.

The excavation for the dam foundation was



Completed Foundation Excavation Showing Steel Trestle and Conduit and Traveling Cableways and Concrete Tower practically completed for a length of 500 ft. in June, 1906, the spoil having been removed by wheelbarrows, carts and dump wagons, successively, and finally by wooden skips and steel buckets handled first by derricks and afterwards by cableways. The bed of the river was at El. 207 and the surface of the rock at the lowest point was at El. 185. It was, however, of such quality that it had to be excavated in some places to El. 170 in order to secure a satisfactory foundation for the masonry. Care was taken to leave the surface as irregular as possible, to bond with the masonry, offer the greatest resistance to transverse displacement and render the connection watertight.



General View of the Cross River Dam Looking North, Showing Derricks and Cableway Towers.

The general character of the rock is clearly shown in one of the accompanying views, looking south, which shows the site nearly ready for the masonry. Care was taken to wash the surface of the rock thoroughly with wire brushes and hose. Seams were grouted and the surface of the rock was covered with 1:3 mortar to improve the bond between the rock and the masonry.

Little difficulty was encountered with the water, most of it being due to surface drainage which was removed by two steam pumps with 6-in. suction pipes and three smaller ones. These were operated only about half the time and had an average lift of about 20 ft. The maximum lift was about 50 ft., discharging into the flume at El. 222.

When springs were encountered, masonry walls were built up around them and two temporary 1½-in. wrought iron vent pipes were connected to them to afford means of controlling them. The springs were thus handled without difficulty, the water from them rising to a maxmum height of about 15 ft. in the pipes. After the masonry was built to a sufficient height, the discharge pipe of a grout pump was connected with one vent pipe and the pump was operated until pure grout was forced out of the other pipe. The latter was then closed with a cast iron plug and hand pumping was continued until no more grout could be forced in, thus effectually sealing the spring.

The mixing machines in the tower deliver 1:3.2:5.8 concrete to 2-yd. Cyclopean steel buckets on cars, which transport it to the longitudinal cableways by which it is delivered to derricks wherever required on the dam. Part of the backing is obtained from a quarry on the hill adjacent to the south end of the dam, and delivered from it by a surface track to the longitudinal cableways. The remainder is obtained from the quarry on the opposite side of the river and is delivered by cars to the middle of the downstream face of the dam, where it can be hoisted by three derricks feeding three other derricks on the upstream face of the dam. The stone is exceedingly irregular and is quarried in blocks of all sizes up to 4 cu. yds.

The work of laying cyclopean masonry is done by gangs of nine men and a derrick man for each derrick, two being masons, six laborers and one foreman. A bucket of concrete is dumped in a low place on the dam, spread, and the stone is deposited on it and thoroughly shaken with bars until it is firmly seated, the entrained air and water are worked out, and there is no danger of any spaces remaining vacant below it. Special care is taken to avoid continuity in the beds of stone and to maintain a clearance of at least 6 in. between them. The best face of the stone is selected for its bed, preference being had for a convex or pointed surface that will engage in the concrete and avoid the formation of a trap and promote the escape of entrained air. Whenever masonry work is resumed in the morning or at noon, a quantity of cement mortar is carefully spread over the surface of the masonry to insure richness in the concrete and improve the bond between the old and the new work.

At each derrick there are two 8 x 8-ft. landing platforms made of two crossed layers of ties bolted together, on which the skips and buckets are lowered from the cableway. The rapidity of operation, the length of span and the sway due to the cableway make this provision necessary to avoid impact and injury to the masonry. One platform can be occupied by a bucket or skip while the other is free to receive a second one.

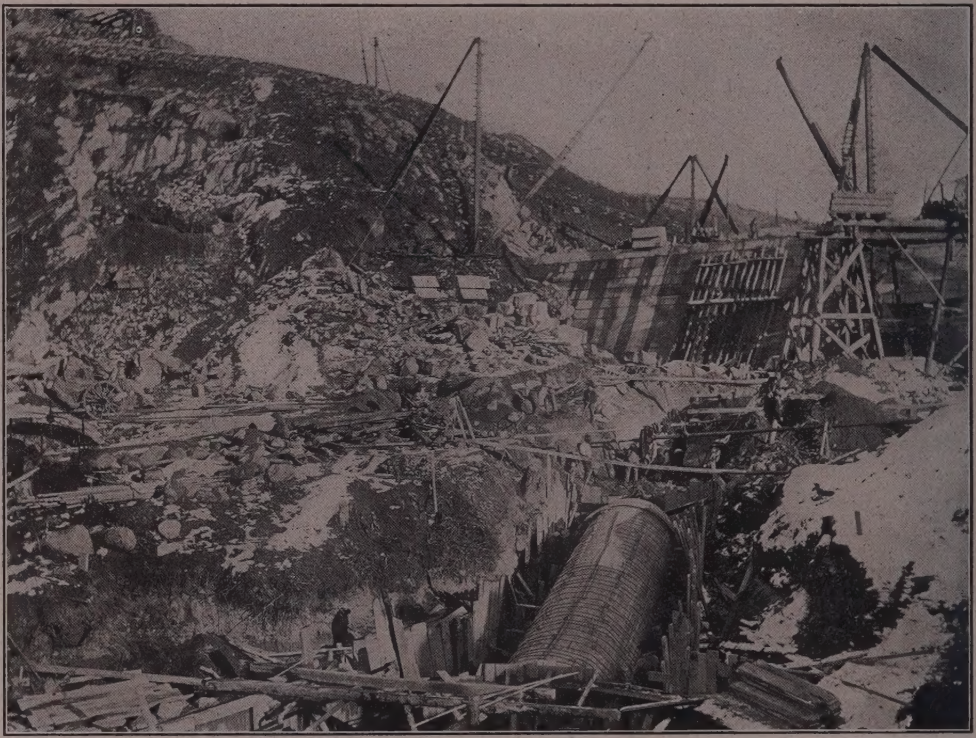
The masonry materials are handled by three cableways and by twelve stiff-leg derricks in staggered rows on the opposite sides of the dam. Four derricks have 60-ft. booms and eight derricks 54-ft. booms and all are operated and swung by Lidgerwood or American Hoisting & Derrick Co.'s engines run with compressed air. At first the derricks were seated on the ground but as the masonry rose they were transferred to the tops of wooden towers. As the masonry is built up and extends beyond the reach of the derricks, new towers are built on which to place the derricks at a higher elevation. The derricks are picked up by the cableways complete, except the stone counterweights, and put in place on the new towers. This transfer is accomplished with ease and rapidity, often being done during the noon hour or after work at night, thereby saving any delay to the masonry gangs.

The arrangement of the derricks on both sides of the dam leaves the entire surface of the masonry unobstructed and provides for maximum rapidity of construction, as can be seen in one of the illustrations, where the full sweep of the work is well shown. Two of the cableways are normally used to furnish concrete to the derrick gangs on the upstream and downstream faces of the work. They deliver it in regular rotation from one end of the dam to the other, then return to the beginning and so on. The third cableway usually delivers stone to the crusher. The cyclopean stones are principally delivered to the derricks at night by all three cableways. The best record for one day's work is 245 2-yd. buckets of concrete, twelve 2-yd. buckets of mortar and some stone, handled by two cableways in ten hours.

One 12 x 12-in. horizontal sill, 18 ft. long, for two stiff legs of each derrick on the downstream face of the dam, is supported on the battered masonry by bent steel straps permanently built into the horizontal joints between the successive courses of cast blocks. The straps are made of 2x6-in. steel set in shallow grooves cut in the tops of the blocks across the upper course. One end of the steel bar is bent down at 90 deg. over the vertical inner face of the block and the other end, projecting about 2 ft. beyond the masonry, is bent down first against the battered face and then extended horizontally 12 in. to receive the sill timber, with a short vertical flange at the extremity pierced with bolt holes. The sill is seated in several of these straps and the lower surface of the timber is additionally supported by short inclined struts with their feet seated in similar steel straps made of 6 x ½-in. bars fitted in the joint of the course next below. The lower bars differ from the upper ones in that they extend only half way across the width of the blocks and are bent at 90 deg., like dog irons, and engage short vertical holes drilled in the blocks.

After the masonry was commenced, it was found that the maximum requirements of power for the derricks, in addition to all of the other plant in simultaneous operation, although not beyond its capacity, was too great for the economical operation of the central power plant, and three independent 100-h.-p. horizontal boilers were installed to furnish steam for the 250 h.-p. engine which operates the mixing plant and rock crusher. Besides this addition to the plant enumerated in the article of June 16, there have been installed eight of the ten derricks located on the dam, four derricks and six Ingersoll-Sergeant steam drills in the new quarry. The other plant remains substantially as described in the previous article. About 86,500 cu. yd., or a little more than one-half of the total amount of masonry, has been laid since June 1, 1906, care being taken to keep the upper surface within 2 or 3 ft. of a horizontal plane which is now at about El. 263, more than 50 ft. above the bed of the river. The two permanent 4-ft. cast iron discharge pipes have been built into the base of the dam and have been fitted with gates at the upper end. These are to be controlled from the top of the dam and therefore cannot be put in service at present. Those at the lower end will be operated at the low level and are to be installed immediately, and it is therefore possible by a few days' work to put these gates in position, after which they can be closed and render the dam available for storage purposes, thus justifying the emergency construction by impounding water this winter.

The concrete face blocks are built up one course in advance of the cyclopean masonry and are laid in 1:1 Portland cement mortar mixed by hand in steel skips located wherever required on the dam. The blocks are cast at least three months before they are used and are being manufactured at the rate of about 350 to 500 cu. yd. per week, while about 300 to 400 cu. yd. per week are built into the dam. The casting yard has a capacity for about 200 forms which, in favorable weather, are refilled every four days. At present there is a total of about 6,000 cu. yd. of blocks in storage. Backing stone is quarried at the rate of about 17,500 cu. yd. per month and about the same quantity has been used during the summer, so that the surplus of about 7,000 cu. yd. on hand at commencement of masonry in the early summer remains in reserve at the present time. About 35 per cent. of the cyclopean masonry is backing and requires 0.75 bbl. of cement per cubic yards. Mortar and concrete are made with Giant Portland cement, about 5,000 bbl. of which are kept in storage at the site.



Part of Dam and Conduit from Below.

In consideration of the fact that the cyclopean stone is used practically as quarried, and that no delay is involved for dressing it, it was decided by the contractor to be advantageous to maintain only this initial surplus, equivalent to about two weeks' supply: therefore the output during the summer has been regulated to correspond with current requirements.

In the upper quarry a face about 60 ft. high and 240 ft. long has been worked to great advantage, several remarkably effective blasts having been made. In one instance 3-in. holes about 26 ft. deep and 6 ft. apart were drilled from 24 to 30 ft. back from the surface and were sprung three times in succession, first with six sticks of dynamite, then with eighteen and finally with thirty or forty sticks in each, thus making very large cavities in which black powder to the amount of about 2,200 lb. and 800 lb. of 40 per cent. dynamite were charged. This last blast resulted in throwing down 5,000 cu. yd. of stone. At another time a similar row of holes was charged with 2,800 lb. of powder and 1,000 lb. of dynamite and secured about the same amount of stone.

Laying masonry is now suspended for the cold weather, but the contractors have plenty of timely work in excavation at the ends of the main dam, for the spillway and the waste channel, and in other operations that can be advantageously conducted through the winter. The present force employed averages about 400 men. The force employed since the injunction has varied from 400 to 700 men. It has been estimated by different disinterested contractors familiar with such work that the plant installed has a nominal value of at least 25 per cent. of the contract price for the work. Much of it had been previously used on other work of a similar character but many thousand dollars' worth of new apparatus was purchased for this work. During last summer the maximum amount of masonry laid per month has been 18,600 cu. yd., which, considering the dimensions of the dam and the number of derricks employed, is believed to be a high record. Under present conditions it is thought that the dam may be completed by August next. The original schedule contemplated a maximum progress of 20,000 to 25,000 cu. yd. of masonry per month during the second season.

The concrete mixer and all of the conveying and handling plant were designed and arranged with the intention of mixing 2½-yd. batches of concrete and handling it in 2½-yd. units. The contractors have, however, been limited to 2-yd. units and as these cannot be mixed or handled with any material diminution of force or increase in speed, it is their opinion that the maximum progress of the work has been 15 or 20 per cent. less than it would have been if 2½-yd. units of concrete had been handled.

Besides the work on the main dam, a large amount of the other work required by the contract has been executed during the past summer. Trees have been cleared from about 350 acres of the reservoir site and two saw-mills have been operated, making 1,500,000 ft. of timber, nearly all of which has been used at the dam. Fifteen houses and many small buildings have been removed. Three miles of highways, including concrete and pipe culverts, have been constructed. All of the spillway excavation and about one-half of that required for the waste channel has been completed. The controlling works, conduit and pool have been finished except the paving. During the winter it is expected that the remainder of the excavation will be completed, which will probably furnish from 15,000 to 18,000 cu. yd. of stone suitable to be crushed for concrete.

The plant installed at the dam since June, 1906, includes three 100 h.-p. boilers to furnish power for crushing and mixing plant. ten stiffleg derricks, with booms 54 to 60 ft. long, and two 90-ft. guy derricks in the new quarry at the downstream face, north end of dam. The principal items of work done during the past year include 110,000 cu. yd. of earth excavated, 71,000 cu. yd. of rock excavated, including quarries, 12,500 cu. yd. of concrete blocks built, 6,500 cu. yd. of concrete blocks set in dam, 77,000 bbl. of Portland cement used, 77,000 lin. ft. of boundary walls built, and 87,500 cu. yd. of masonry in dam. About 63 per cent. of the basis of award has been completed to date. Laying masonry in the dam was commenced May 27, and six ten-man mason gangs have been employed since July 1.

View of Concrete Block Yard and Finished Blocks, Cross River Dam.

Mr. Walter H. Sears is the chief engineer, and Prof. William H. Burr is the expert engineer for the Croton Aqueduct Commissioners. MacArthur Brothers Co. & Winston & Co. are the contractors, and the work is being executed under the personal direction of Mr. James O. Winston.

SUBMARINE TELEPHONY has been successfully accomplished through a seven-mile cable under Lake Constance, in Switzerland, recently laid. The cable is fitted with self-induction coils on the Pupin system for counteracting the effects of capacity, and conversation was successful from the time of completion of laying. Conversations have also been successfully held through this cable and overland lines to Berlin, a total distance of over 400 miles. Some difficulty was at first experienced in laying the cable owing to the enlargements in the sheath at the points where the load coils are encased, but a special gear was finally devised by the contractors, Siemens & Halske, by which it might be paid out with the proper tension, irrespective of the enlargements.

The El Paso & Southwestern R. R. Shops

By J. L. Campbell, M. AM. Soc. C. E., Engineer of Maintenance of Way, El Paso & Southwestern R. R.

The El Paso & Southwestern R. R. is owned and operated by Phelps, Dodge & Co., of New York, in connection with their copper mines and smelters, and coal and timber fields in Arizona, New Mexico and Mexico. It is one of the largest standard gauge industrial roads in the country, having, as it does, a mileage of 883 miles. With the exception of the original line from Benson to Bisbee, Ariz., a distance of 66 miles, the entire system has been created in the last ten years. It is, in consequence, an up-to-date road, comparing favorably with the transcontinental lines of the Southwest.

It lies partly on the Pacific and partly on the Atlantic slope of the southern extremity of the Rocky Mountain Plateau, and crosses the continental divide on a 1 per cent. grade, which is also the maximum for main lines. The maximum curvature for the main lines is 6 deg., and there are one tangent 43 miles long, one 22 miles, two 21 miles, one 19 miles and a goodly number of 5 to 10 miles in length.

On the branch lines there are some notable features. Of these, the Alamogordo & Sacramento Mountain R. R., a standard gauge lumber line, rises from an elevation of 5,000 ft. at Alamogordo, N. Mex., to an elevation of 9,000 ft. at Cloudcroft on the top of the Sacramento Mountain, an ascent of 4,000 feet in a developed distance of 26 miles on 30 deg. curves and 5 per cent. grades. At Bisbee, Ariz., one of the largest copper camps in the United States, a complete network of tracks girdles the hills and serves the numerous mines. At Douglas, Ariz., the great smelters are likewise served.

The standard weight of rail is 80 lbs. The roadbed is being ballasted by smelter slag and crushed rock, about 90 miles being completed.

Being a new road, the equipment is up-to-date; the ore, coal and coke cars being built entirely of steel, and of 100,000 lb. capacity, while the average weight on locomotive drivers is greater than on any other road in the Southwest. The daily ore trains from Bisbee to Douglas carry regular train-loads of 3,500 tons.

The road originally extended from Benson, Ariz., to El Paso, Tex., with a branch into Mexico. To place the production of their mines and smelters on a permanently economical basis, Phelps, Dodge & Company set out in 1904 to acquire the necessary fuel supply. The result was the purchase of the El Paso & Northwestern R. R., running from El Paso, Tex., to Dawson, N. Mex., a distance of 464 miles, and the purchase of 45,000 acres of fine commercial and coking coal at Dawson, including a large coking plant which is now being enlarged by the addition of 400 ovens. The road thus renders the double service of bringing the ores from the West and the fuel from the East to the smelters. In addition, it carries the traffic for the great copper camp at Cananea, Mexico; has a large local business; and it is the connecting link between the Rock Island at Santa Rosa, N. Mex., and the Southern Pacific at El Paso, the Rock Island's California and Mexico business being carried over the Eastern Division of the road.

To maintain the equipment for this traffic, the railroad shops forming the subject matter proper of this article have been built at El Paso, Tex. This place is the geographical and traffic center of the system; it is a hustling, thriving Western city, with splendid railroad facilities, and a rich mining country of 400 miles radius surrounding and tributary to it.

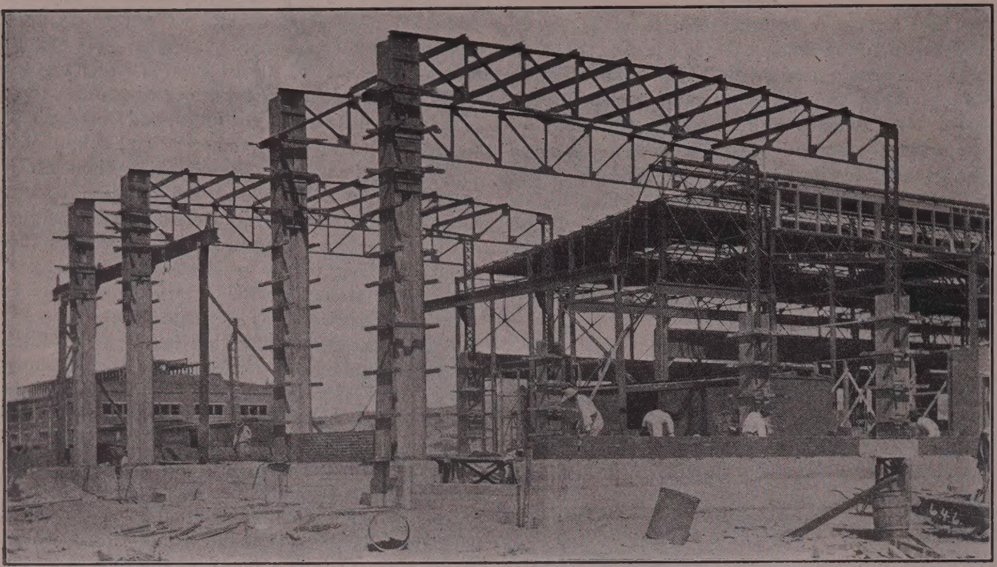
Accordingly, a tract of 64 acres of land, adjoining and forming an extension of the existing yards in El Paso, was purchased in the spring of 1905 and the construction of the shops begun in August of that year. The work is now complete. The buildings, except the interior of the roundhouse and the store house, are built of concrete, brick and steel. The following is a list of the principal structures: a 21-stall round-house 85 ft. deep, a machine shop 137 x 320 ft., a smith shop 70 x 100 ft., a mill building 80 x 200 ft., a paint, coach and cabinet shop 110 x 208 ft., a transfer table and pit 75 x 400 ft., a store house 60 x 200 ft., a power house 50 x 100 ft., an oil house, a coaling station of 800 tons daily capacity, underground concrete fuel oil tanks. There are complete systems of water supply, drainage, sewerage and fire hydrants for all buildings and storage platforms and tracks, the city water and sewer mains crossing the grounds.

Foundations and Footings.—The shop site lies in the Rio Grande valley, and all trenches and pits for the foundation footings and walls extend down into a deep bed of fine, clean sand. All excavations were thoroughly slushed with water before any concrete was placed, the result being ideal foundations of great uniformity and sustaining power, in which settlement, if any, will be evenly distributed throughout.

The pressure on the sand is limited to one ton per square foot for moving loads and two tons for static loads. There is no doubt that these could have been increased 50 per cent. without harm, but the necessary widths of footings to carry the superstructure dimensions of walls, etc., generally required but slight additional widths to keep within the above maxima. In the case of isolated piers carrying heavy loads, wide and comparatively thin reinforced footing slabs were used, resulting in economical foundations. The result of these excellent foundations is seen in the total absence of any settlement cracks or appreciable settlement in all structures.

All foundation footings and walls are exclusively of 1:3:5 concrete. In all engine pits, transfer pit, ash pit, turn-table pier, etc., subject to moving loads, the concrete footings and walls are reinforced throughout, resulting also in the absence of any cracks as well as appreciable settlement.

Portland cement of a half-dozen different brands was used. Each shipment was stored and tested on the ground before using. Occasionally a lot was rejected, but, with rare exceptions, all of it met the requirements, the tests recommended by the American Society of Civil Engineers and the specifications of the U. S. Government Service.



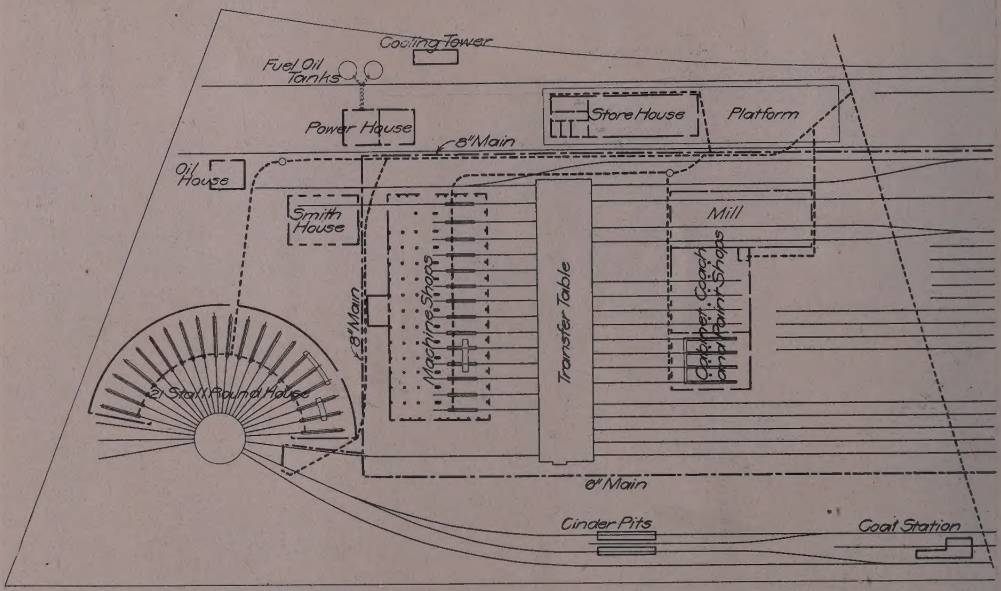
Reinforced Concrete Columns and Steel Trusses of Power House.

Reinforced Concrete.—A special feature of reinforced concrete is found in the reinforced columns carrying the steel roof trusses of the oil house, power house, smith shop and mill building having clear spans of 40 to 80 ft. A reference to the photographs showing these columns in various stages of construction will give a clear idea of their character and function in taking care of all roof loads and stresses carried by the trusses. In addition, they add materially to the stability of the walls.

In the smith shop and mill building, these columns were erected first and the roof trusses afterward erected on and riveted to them, a vertical angle being run up throughout the length of the columns and properly punched for the riveted connection to the truss at the top. Afterward the column was carried on up around this connection and enclosed the end of the truss level with its top chord. The reinforcement of the column extends from the bottom of the foundation footing to the top of the truss. The erection of these columns required great care and precision, since they had to fit not only the length of the truss across the span, but the lateral connections between the trusses also. Fortunately, all the connections came out admirably without the necessity of any repunching or modifications of the details.

The care, time and anxiety involved, and the rather expensive forms required in maintaining the alignment of the columns in two directions as they went up, led to the adoption of a different method of reinforcement in the columns of the oil house and power house. Indeed, this last method was the one originally outlined but temporarily laid aside for the one above described. It consisted in first erecting the roof trusses on light latticed steel columns containing metal in quantity and position sufficient for the reinforcement. After the trusses were so erected and the lateral connections made, it required only ordinary care to build up the concrete around the steel expeditiously and economically and with absolute certainty that everything was all right. In each side of each column there is a groove into which the brick walls were mortised as they were laid up after the columns were finished.

In the oil house, however, after the steel was all erected, the brick walls were next built with the required tenons on the faces to connect to the columns. The latter were then molded into place around the steel and brick. This method required practically no form work, gave the best union between brick and concrete, and is the one that the writer would follow in the future. Inasmuch as the brick walls were laid in cement mortar, the construction as a whole is very strong and rigid.



General Plan of New Shops, El Paso and Southwestern R. R.

In the power house, the columns also carry the tracks carrying the 10-ton hand crane, while heavy lines of shafting are carried on the trusses in the smith shop and mill building. Where the latticed steel columns were adopted as the reinforcement, their anchor-bolts extend down to the bottom of the concrete foundations.

Another feature is the use of straight reinforced concrete sills and lintels for all doors and windows, except in the south end of the machine shop, where a reinforced arch spans the wide opening for the passage of a 10-ton electric crane.

Over all engine door openings, the clear span of the lintels is 12 ft. Two of these lintels tested to destruction were 12 in. wide, 11½ in. deep from top to center of steel, and 12 ft. span. The first one failed when the distributed load on both was 68,000 lb., and the second one with a like load of 72,000 lb. The deflection of the first was 1⅛ in., and of the second 1 in. when appreciable crushing of the concrete began. Both beams settled and crushed slowly through a period of about 20 seconds each. Both were reinforced against shear. Below the steel only two small cracks showed in each beam in the middle of the span

Engine Room of Power Station.

under the crushed top. These lintels and all others were made of 1:2:4 concrete. All sills were cast on the ground, but all lintels were cast in place on the walls.

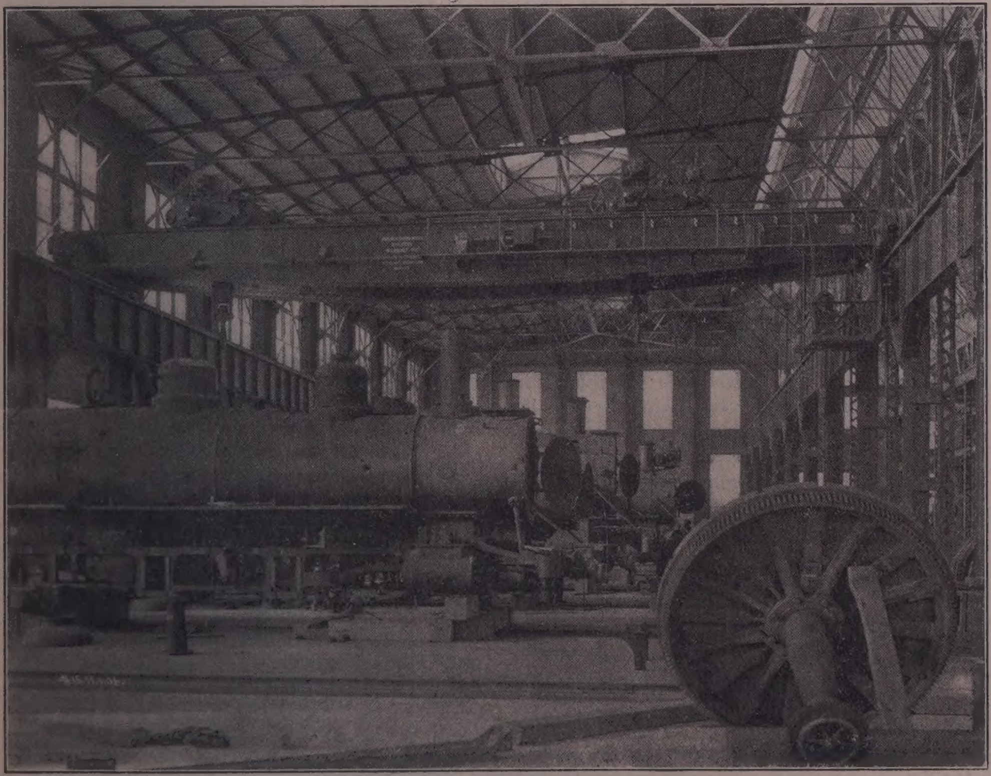
The combination of the concrete columns, sills and lintels with the red brick of the walls gives a pleasing and finished appearance to the buildings.

The oil house is a fireproof building with a reinforced concrete floor over the basement. All its windows are provided with screens. The fuel oil tanks are also of reinforced concrete. They are built under-ground in the rear of the power house. They are covered with flat reinforced slabs whose tops are about 4 in. above the top of the adjacent power house yard track and will take oil directly from the cars through an 8-in. receiving pipe opening upward in the middle of the track, as shown. Before these tanks were built, a small test-tank of 1:2:4 concrete was built and filled with oil to determine the penetration and effect of the liquid on the concrete. At the end of 9 months, this test-tank is still full of the original oil, the level of the latter having fallen in that time only ⅝-in., due doubtless to evaporation, as the tank proved absolutely tight, the oil penetrated and discolored the concrete less than 1½ in. The latter is apparently still entirely sound and uninjured.

In no case has there been any failure of any of the reinforced concrete above described.

Woodwork.—Wood was used in the interior of the round house and in the floors of the machine shop and mill. In the round house it was used as being preferable to steel on account of corrosion, and to reinforced concrete as less expensive. For the same reasons, the doors, when installed, will be wood slat rolling doors.

In the floors of the buildings specified, wood was used in preference to concrete in deference to the opinion of the superintendent of motive power that concrete was very tiresome on the feet and legs of the men standing all day about the machines. These floors are spiked to timber sleepers embedded in clean sand, slushed down and dressed flush with the tops of the sleepers, the floor being in full contact with the sand. This makes a very solid floor. A concrete floor in the machine shop would have cost $1,500 less than the wood.

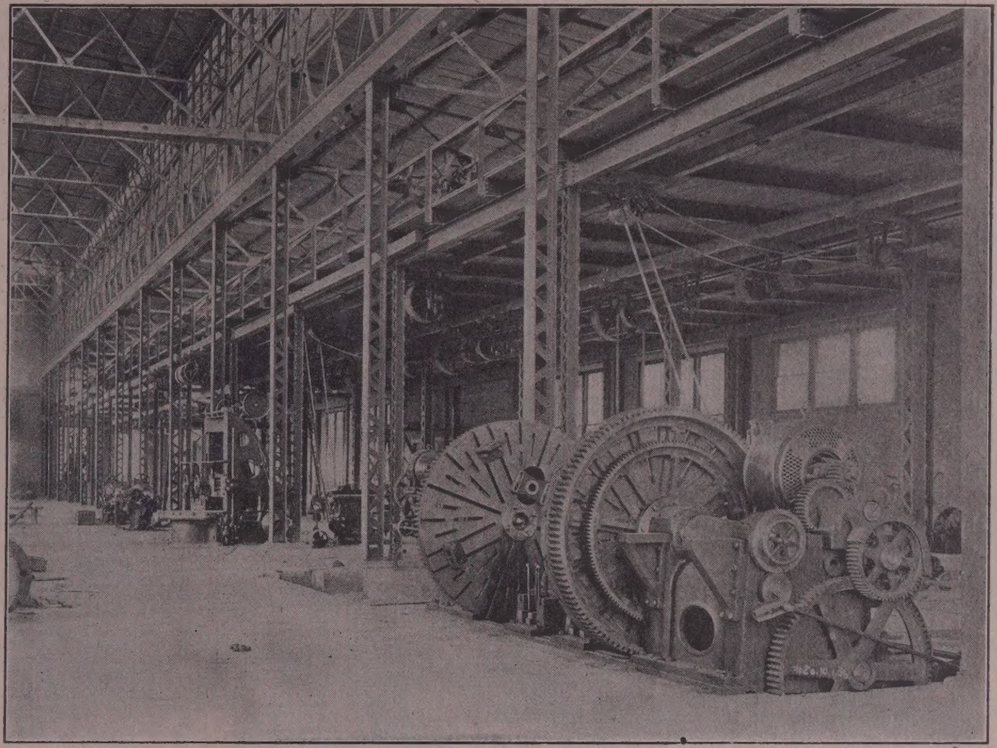


View Down Main Aisle of Machine Shop

Doors and Windows.—All door-openings for the passage of engines and cars in the various buildings are 12 x 17 ft. in the clear. Each door is built in three counter-balanced sections lifting vertically and telescoping like the sashes of a window, the upper two sections, in fact, being filled with corrugated glass lights.

The buildings are liberally provided with light. The ventilators and, generally, the upper lines of windows are hinged, each line of lights being opened and closed by one line of sash operator worked from the floor. All lights, except in the office end of the store house, are of corrugated or ribbed glass, giving a diffused light.

Roofing.—The buildings are covered with three-ply Ruberoid roofing, under the contractor's guarantee of 5 years and the manufacturer's guarantee of 10 years. On account of the light rainfall at El Paso, 10 in. per year, this roofing was adopted on account of its inexpensiveness, but it may be a question whether this was altogether wise. It has been discovered that it suffered some damage on account of the workmen tramping on nails, broken glass, etc., dropped on the roof during the erection of the skylights and ventilator lights, resulting in a number of leaks during a recent heavy rain. However, this could hardly be charged to the roofing, but rather to an improper order of work.



Side Aisle of Machine Shop

Water Supply and Sewerage.—An 8-in. city water-main passes between the principal buildings, from which all necessary water connections are taken, including 6 and 4-in. branches. This 8-in. main will be connected at both ends to the water works system and will maintain a normal pressure of 80 lb. There are 10 fire-hydrants conveniently located about the shop grounds and buildings.

A city 18-in. sewer line crosses the grounds. The drainage and sewerage of the shops are conducted to this through 12 and 8-in. vitrified pipe. The drainage of the round house, machine shop and coach and cabinet shop is first collected in large, specially constructed settling basins, and the sludge, grease, etc., collected there and kept out of the city sewers.

Mechanical Equipment.—The entire terminal plant is operated by electric and pneumatic power generated in a central power station. The direct current electric power is generated by three separate units, each consisting of a steam turbine and a generator mounted on a single base and shaft.

Messrs. Frank Powers and Sorenson & Morgan, of El Paso, were the contractors for the buildings. The Missouri Valley Bridge & Iron Works, of Leavenworth, Kan., fabricated and erected the steel frames of the buildings; Pawling & Harnischfeger, of Milwaukee, manufactured and erected the 100-ton crane; Geo. P. Nichols & Bro., of Chicago, made and installed the transfer table, and the Link-Belt Machinery Co., of Chicago, erected the coaling station.

The work as a whole was under the management of Mr. H. J. Simmons, general manager of selected and is installing the mechanical equip- the road. Mr. Thos. Paxton, superintendent of motive power, planned the ground layout and ment. The buildings, etc., were designed and erected under the direction of the writer.

Experiments in Distribution of Sewage over Sprinkling Filters at Waterbury, Conn.

By Wm. Gavin Taylor, Resident Engineer, Sewage Disposal Works, Waterbury, Conn.

The great importance of rapid filters of the sprinkling type, for the purification of sewage at high rates, has led to much study and many experiments upon distributors of various types, in England and our own country. Coarse grain sewage filters have passed through a rapid evolution since their first trial, on a large scale, in England. The type has proved its worth and secured adoption in numerous communities in England, and is being introduced at several sewage disposal works now under construction in the United States.

From the first the difficulty and almost impossibility of obtaining a perfectly uniform distribution of the sewage over the surface of the filter area has been appreciated. Evenness of distribution has been recognized as highly desirable, in fact essential for ideal results. Unequal application of sewage to the surface of this type of filter has a marked effect upon the quality of the effluent and the working capacity and efficiency of the bed. Owing to the character and large size of the material composing the filter, the rapidity of the vertical flow, and the small lateral motion of the sewage in passing through the bed, it is evident that any inequality in the distribution of the sewage upon the surface will cause a like inequality in the working rates within the filter.

From experiments it has been learned that a change in the degree of uniformity of the distribution of the influent over the filter surface has a rapid and marked effect upon the quality and stability of the effluent. Suppose a filter is capable of purifying sewage at a maximum rate of 2,000,000 gal. per day, and that one-third of the area is receiving sewage at this rate while the remaining portion receives only one-half the quantity. It is evident that the total output of the bed is only two-thirds of what it should be. Perfect distribution requires that each unit area of the surface shall receive sewage at an equal rate. Such a distribution may be compared to that attained by a gentle rain. The effectiveness of distributing devices may be represented, for comparison, by a scale of coefficients, the ideal condition—that is, perfect distribution—being represented by a coefficient of unity.

In practice sewage has been disseminated by various types of distributors, which we may divide into two general classes: 1, movable devices, and 2, fixed devices. These two classes may be sub-divided as follows:

Movable.—(*a*) Rotating arms, driven either by the sewage itself or by power, revolving over circular beds and distributing the sewage through perforations, orifices or notches, or discharging a thin film over the side of a trough. Numerous devices under this class have been developed and used in England with varying success. Certain distributors of this type have failed to give uniform distribution, and much difficulty has been encountered from the existence of small orifices and from the collection of clogging matter within the device.

(*b*) Traveling carriers, driven by power, have been operated in England and have been proposed for use at the sewage testing station at Baltimore. Such distributors may operate over a rectangular bed, by traveling backward or forward from one end of the filter to the other, or they may rotate about a central axis. Good efficiencies have been obtained by this type. The cost of installation, operation and maintenance of distributors of this type is, doubtless, much greater than for some others.

2, *Fixed.*—(*c*) Troughs placed over the filter bed and designed to overflow or to discharge through notches or perforations. A number of such distributors have been constructed in England, some being fed intermittently by automatic syphons, others being operated continuously. Filamentous fungus growths have frequently been the source of much trouble in this type.

(*d*) Nozzles operated under pressure or by gravity. The distribution under this system is effected by the discharge of sewage from fixed sprinkler heads spaced regularly over the filter surface. They diffuse the sewage fed to them from nozzle mains located either above or below the surface of the bed.

In the northeastern portion of the United States, where the winters are severe and low temperatures exist for many consecutive weeks, it is in general impracticable to attempt to distribute sewage by rotating devices, owing to the difficulties arising from the formation of ice and the operation of the distributors during and after storms. The cost of operating and maintaining movable or rotating devices is in most cases very much greater than need be borne with fixed sprinkler heads of proper design.

The condition of low winter temperature and the need of economy in operating expenses has restricted the study of distributing or sprinkling apparatus at the Sewage Experiment Station at Waterbury to the development of only such devices as could be classed under the fourth subdivision. The application of sewage by fixed sprinkler heads, operated under pressure, is believed to be the best method for the work in this city. Many designs of sprinkling nozzles have been tested. The avoidance of numerous openings was at once appreciated, and the advantages arising from the discharge of the sewage through a single orifice and the securing of large waterways within the nozzle were apparent. Numerous attempts were made for the side support of a single cone, over the axis of the central orifice, to effect a diffusion of the sewage into an umbrella-like spray. No satisfactory method of attaching the cone could be found. Difficulty was caused by the vibrating of the cone when in use and by an interruption in the continuity of the spray by the side supports. Even after these objections were overcome and a steady, self-healing and continuous spray could be obtained when the nozzle was first put in operation, it was found that the self-healing quality and consequently the continuity of the spray were not permanent, owing to the collection and growth upon the side supports of a long, filamentous fungus.

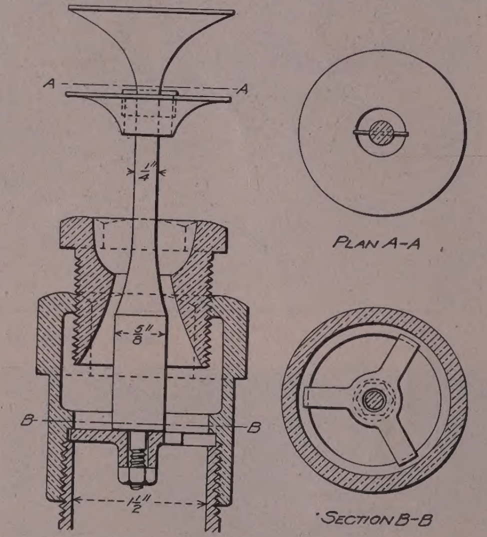


Fig. 1. Adjustable Perconate Nozzle.

The uniformity of distribution obtained by means of a single cone, acting under a head of 5 ft., was not satisfactory. Although the efficiency as marked by the area wetted was approximately 75 per cent., a certain outer zone invariably received sewage at a higher rate than the inner area. To lessen this defect and to secure a greater percentage of wetted area and a more uniform distribution of the sewage, the idea occurred to the writer of placing a lower and secondary cone over the orifice with the object of intercepting a portion of the sewage and distributing it over the inner fifth of the circular area within the range of the nozzle. The result was effected by boring a hole through the lower cone slightly less in diameter than the fixed orifice in the nozzle, the diameter of the opening in the cone being so proportioned to the diameter of the nozzle orifice that four-fifths of the rising stream passes through the lower cone to be diffused by the upper and the remaining fifth is sheared off by the lower cone and sprinkled over the central area. Better results were given by the double than by the single cones.

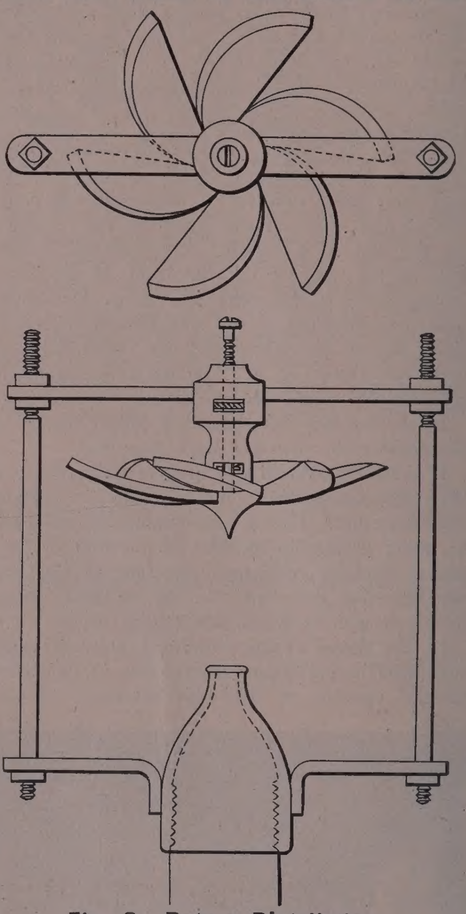


Fig. 2. Rotary Distributor.

While a wetting of the entire surface was accomplished, and the distribution showed a marked improvement over that given by the single cones, it was far from perfect, the fundamental defect being the same in both styles. The construction of the double cone nozzle is shown in Fig. 1.

In the development of the Waterbury sewage disposal works the surface of the filters will be at different levels, the differences being such as to secure pressures upon the nozzles varying from 7.5 to 13 ft. These pressures can either be so controlled by throttling as to produce a constant nozzle pressure throughout the entire plant, or the higher pressures can be used to produce greater covering areas for each sprinkler head.

Many advantages are apparent in the adoption, for a working plant, of a nozzle capable of adjustment to meet the varying conditions of effective head. Such an adjustment has the further advantages of allowing an actual calibration of the nozzle and an opportunity to control the size of the orifice should it become desirable at any time to increase or decrease the working rate of the filter. The desired adjustment may be obtained by forming a cone at the lower end of the central spindle, as shown in Fig. 1, and providing an orifice which may be raised or lowered with respect to this cone, thus effecting a regulation of orifice area.

The sprinkling filters used during the tests were 7 ft. 5⅜ in. in diameter and presented a working area of 0.001 acre. Sewage was applied to these filters at various rates and under a head of 5 ft. Much inconvenience was experienced owing to the comparatively small amount of sewage to be distributed. When the filters were operating at a rate of 2,000,000 gal. per acre per day the sewage was applied to the testing filters at the rate of 0.023 gal. per second. The problem of distributing so small a quantity was quite different from that to be solved upon a large working plant. After several tests a revolving winged cone was developed, as shown in Fig. 2, which produced a very satisfactory sprinkling of the sewage over the testing filters. The design would not be suitable or desirable upon large areas under working conditions, yet for distributing a small quantity of sewage over a small area it did excellent work.

A perfectly uniform distribution has not been obtained, in our tests, with any form of cone when acting under a fixed head. An outer zone has invariably received more than its proper proportion. If this zone of maximum intensity could be made to travel radially from the greatest range of the sprinkler head to the center of the area, a more uniform distribution could be obtained. Calculations showed that a nozzle acting under a straight-line variation of head, from maximum to minimum, such as that obtained by the discharge of a tank under syphon action, would not produce ideal results, although there would be marked increase in the coefficient of distribution. Study proved that, to produce an ideal distribution upon the area covered, the head upon the nozzle should vary less rapidly near the maximum point than near the minimum. The rate of the required variation in nozzle head was found to be represented by a parabolic line. To produce such a nozzle pressure and velocity variation a valve has been designed to operate through a definite cycle in which the desired undulations are obtained. It is aimed to produce at each instant a nozzle velocity and discharge proportional to the circumference of the circle to be wetted by the spray, this circumference to travel backward and forward from maximum to minimum at such a rate that each infinitesimal arc shall receive the applied sewage at an equal rate.

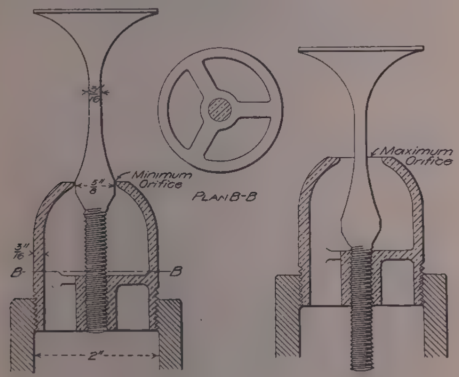


Fig. 3. Adjustable Sprinkling Nozzle.

For use with the above undulating device a simple form of adjustable nozzle, which may be made at a comparatively low cost, has been designed, Fig. 3. The dome of this nozzle is of cast brass, threaded at the lower end to screw into a vertical riser. The orifice and central nut are bored with coincident centers and the nut is tapped for the central spindle, which is capable of being raised or lowered to regulate the orifice areas. The spindle and cone are of brass, cast smooth, tapped and finished by a buffing wheel.

In the construction of large sprinkling filter areas the nozzles are usually spaced at regular intervals. Each nozzle has therefore a square area which it should in theory cover. Assume that a nozzle can be made to cover uniformly a circular area whose diameter is equal to the side of the square between the nozzle heads, the coefficient of its distribution would be the quotient obtained by dividing the area of the circle by the square, or 0.78. Nearly one-fourth of the whole filter area does not, therefore, receive its proportional part of the work to be done. Any method of increasing the coefficient above 0.78 is of great value, but to do so by fixed sprinkler heads it is necessary to design a nozzle which is capable of spraying over a square area. Experiments have been made with a nozzle in which the cone is so shaped at its top that the sewage film when leaving shall have such varying angles of elevation that it shall upon diffusion throw the proper proportion of drops the distance required to cover the side of the square, while midway between these points, on the diagonal lines, the drops will by reason of their greater angle of elevation be thrown with the tendency to fill the corners of the square. The theoretical plan of a nozzle to spray over a square surface is shown in Fig. 4. The cone test is designed to operate under a 7-ft. maximum nozzle head and to cover, with the cone placed 12 in. above the filter surface, a square area containing 196 sq. ft. In practice this nozzle has successfully covered more than 90 per cent. of the prescribed square, although it has been found necessary to alter slightly the calculated form of the notches opposite the diagonal lines, owing to the existence of a modifying factor which must be determined by tests. The horizontal distance which a drop travels upon leaving the nozzle depends upon the angle of elevation given to it at the instant it leaves the cone. The cone represented in Fig. 4 provides a gradual gradation in the angles of elevation from a minimum of 5 deg. to a maximum of 34 deg., the horizontal throw corresponding to these angles being 7 and 8.5 ft., respectively. The undulating head device should be used in connection with this nozzle to obtain the highest coefficients. Further tests are under way at the Experiment Station for the purpose of obtaining greater simplicity in the parts and still greater efficiency in the distribution effected.

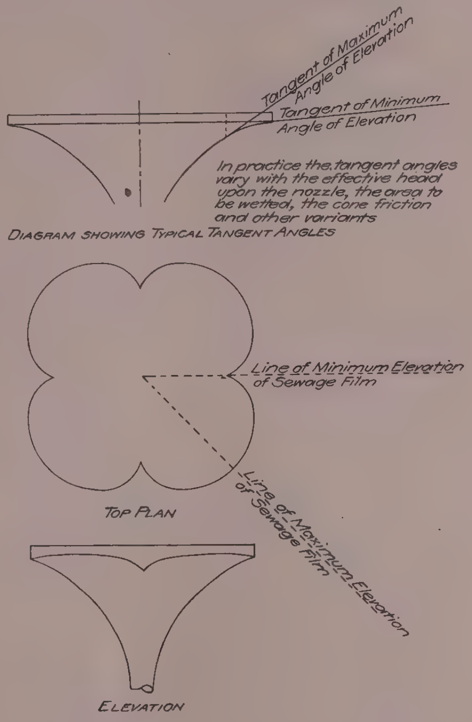

Tangent of Maximum Angle of Elevation
Tangent of Minimum Angle of Elevation
In practice the tangent angles vary with the effective head upon the nozzle, the area to be wetted, the cone friction and other variants
DIAGRAM SHOWING TYPICAL TANGENT ANGLES
Line of Minimum Elevation of Sewage Film
Line of Maximum Elevation of Sewage Film
TOP PLAN
ELEVATION

Fig. 4. Theoretical Form of Cones

The study upon sprinkling filter nozzles, as above outlined, is a part of the experimental work carried on at Waterbury, Conn., during the past year in connection with the design of the sewage purification works. The work is being done under the direction of Mr. R. A. Cairns, M. Am. Soc. C. E., city engineer, with the writer as resident engineer in immediate charge of the design and construction of the works.

The Collapse of a Reinforced Concrete Building near Rochester, N. Y.

As a rule, this journal has little sympathy with the burning zeal shown in some quarters to portray the minute details of every failure of reinforced concrete structures. Very few of them present instructive features, but most are like the many failures of brick and frame buildings, wood and steel bridges, mill dams and such structures that are giving way constantly for some reason that is too apparent to teach anything not already thoroughly well known to competent engineers and contractors. Respectable newspapers do not give space to the lurid horrors that make a yellow paper mainly a record of crimes of various degrees, interesting only to a depraved mind. For the same reason this journal does not care to give up its space to descriptions of the offenses against sound construction which are constantly being detected. A case recently occurred near Rochester, N. Y., however, which is of some interest.

It is well known that the processes followed by the Eastman Kodak Co. in the manufacture of various products are very carefully guarded. Not only are the processes themselves kept secret, but also the apparatus and its general arrangement. The company planned a number of buildings for manufacturing purposes, and their construction was started in Kodak Park, just outside Rochester, some time ago. The general dimensions of the buildings were furnished to a well-known company of reinforced concrete specialists, which worked up the detail designs in that material, so far as practicable, at its home office. The importance of secrecy was considered so great by the owners, however, that a thorough office design was impracticable, and the details were altered for or by the owners' representatives on the spot. This not only prevented any careful planning of the construction methods in advance of the actual work, but also made it necessary to make many changes after operations were begun. Anybody who knows about reinforced concrete construction appreciates the special importance in such work of having the details planned ahead, so that the handling of the forms may proceed rapidly. A few changes after the forms have been built will often make it wholly impossible to carry the work through with the rapidity essential to economical construction in this material. People who have executed reinforced concrete buildings know this, while those without such experience cannot appreciate its full significance. The contractors for the Kodak buildings put on the work men with good reputations for such construction, but it is evident that the constant changes in detail plans and construction methods as the work progressed, made necessary to satisfy the requirements of the carefully guarded secrets of the owners, made the men lose all interest in the work owing to the impossibility of conducting it in a business-like manner. It is not surprising, therefore, although deplorable, that one of the structures collapsed on Nov. 21, killing four men.

The structure that partly fell was the so-called "emulsion" building, and the following statements concerning it, with the illustrations, are from data furnished by Mr. J. Y. McClintock, engineer of Monroe County, who assisted the county coroner in his examination into the accident. About 10 a. m., Nov. 21, a 21x45-ft. section of the mezzanine floor, and a 53x88-ft. section of the roof of this structure collapsed, killing two men and injuring many more, two of whom subsequently died.

In column 37 at the level of the mezzanine floor there was a horizontal joint of sawdust and shavings nearly if not quite through the section, into which a knife blade was easily thrust to a depth of 2½ in. In the north face of the post there is embedded a piece of wood showing a width of 5¾ and a length of about 13 in., and probably 2 or 3 in. thick, as indicated in the sketch. Below the mezzanine floor the concrete was of such a quality that at one place a cavity nearly 2 in. deep could be dug into it. Many of the posts show a joint of sawdust, shavings and paper, and in column 2 a knife blade could be inserted 2 in.

Column 47 collapsed as shown in the sketches. The upper fragment about 7 ft. long was very easily crumbled, and about 2 ft. of its top end was easily picked off with the fingers. The plans showed the column to be 18 x 18 in. to a height of 4 ft. above the main floor and there reduced to 12 x 12 in., but it was actually constructed 12 x 12 in. square from the main floor upward. It was reinforced by four Kahn bars, which were in place, but four ¾-in. round rods which were called for by the plans had been left out.

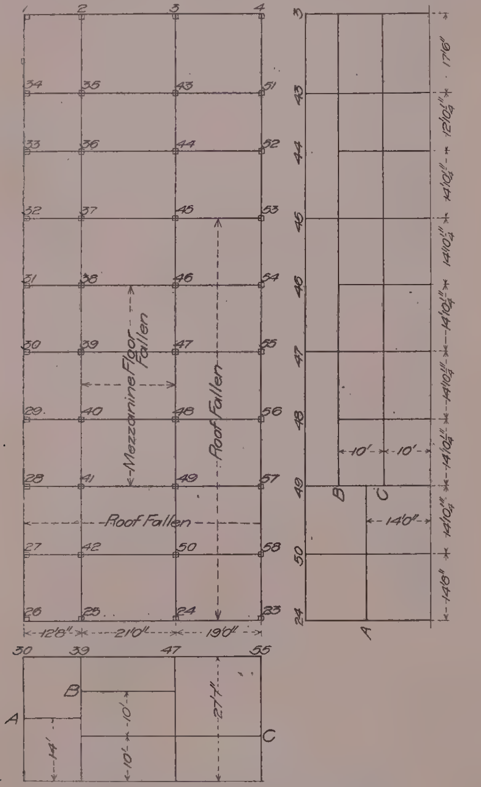


Diagram of Emulsion Building

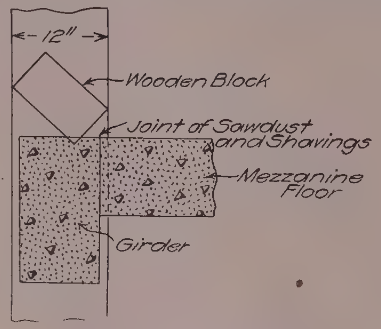
Column 46, which did not carry any roof load, was furnished with extra bars not called for by the plans.

In many places the steel bars showed on the surface of girders. The girder of floor A between columns 39 and 40, for example, had the steel bar exposed for fully 6 ft. In other places the bars in the girders did not enter the columns, and the concrete in some places had the open texture of a popcorn ball.

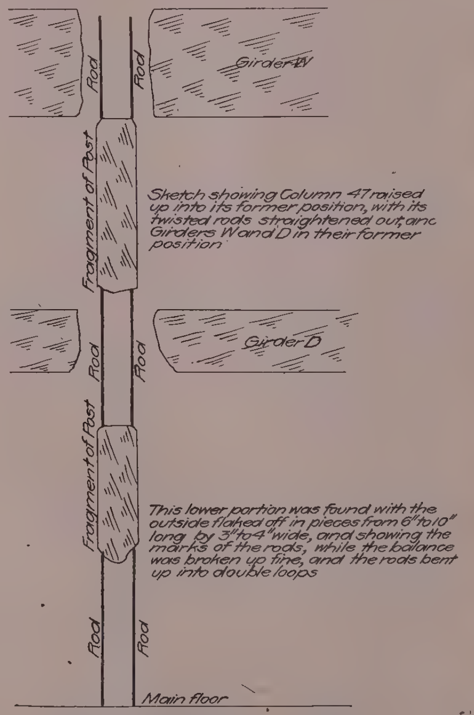
None of the sand employed on the work remained unused, but some of the crumbling concrete indicated that it was very fine and dirty. The crushed stone was ½ to 1 in. in size, with some screenings, and was apparently good ledge stone. The concrete was mixed in a machine. The general condition of the building indicates that the cement was good and that ample time was given for setting before removal of the forms.

In Mr. McClintock's opinion, the building failed by the crushing of column 47, which was loaded to 950 lb. per square inch by the eccentricity of the loading. This it could not support in its defective condition, with part of the reinforcement omitted. This view was also expressed in the coroner's verdict.

A photograph of the remains of this column is reproduced in one of the accompanying illustrations. The conical end in the foreground is the lower end and it probably acquired this form in crushing down through some 4 ft. of its own length. Just above where the distorted bar comes out of the conical end can be seen the end of a steel rod projecting some 2 in. above the floor, and above this are two more; these are three of the four rods coming up from the portion of the column below and marking the exact site on which this column stood.



Wooden Block in Column.



Rod
Rod
Girder W
Fragment of Post
Sketch showing Column 47 raised up into its former position, with its twisted rods straightened out, and Girders W and D in their former position
Rod
Rod
Girder D
Fragment of Post
This lower portion was found with the outside flaked off in pieces from 6" to 10" long by 3" to 4" wide, and showing the marks of the rods, while the balance was broken up fine, and the rods bent up into double loops
Rod
Rod
Main floor

What Was Left of Column 47.

The end of the girder on the left, resting on this fragment of the column, is the mezzanine floor girder which was carried by this column and fell 8 ft., almost vertically. The girder showing in the right-hand lower corner is the roof girder which was carried by this column, and fell 17 ft., almost vertically. It remained attached to the top part of the column, which is shown in the middle of the picture, and was still attached to the lower portion by four much twisted bars. The length of the bars shown projecting from the conical end is 4 ft.; their ends butted on the floor when the column was in place originally and the surface was probably flush with the tops of the rods now projecting from below, the original concrete apparently having been torn and rubbed off by grinding action as the column settled. This end was buried under fragments of concrete and tile, but after it was freed from the overlying debris, the outer portions were found to have broken into large fragments, some of which are shown piled up on top of the girder at the left of the picture. The interior portion was completely disintegrated.

The main floor resisted the shock of the falling columns, mezzanine floor and roof without appreciable injury. The only place in the main floor where a break occurred was at the point where a roof girder between two columns dropped from one of them while held by the other. The end of this girder punched a hole about 3 ft. square in the floor.

In the investigation of the accident the coroner was assisted by Mr. J. Herbert Grant, assistant city engineer of Rochester, by Mr. McClintock and by two deputy fire marshals of the city. The verdict was to the effect that the men were killed primarily by the failure of column 47, as before stated. The men were engaged in removing the falsework under the part of the building that collapsed. The contractor's foreman was found guilty of "criminal negligence" and the assistant manager of the Eastman Kodak Co. was found guilty of "gross and culpable negligence." Both of these men had a good record, and it is for this reason that the accident is of real interest. If concrete is put into molds in which blocks of wood, sawdust and leaves are allowed to fall, and is prepared and placed in such a way that it can be picked to pieces with the fingers, manifestly the construction is poor. That such work should be done under the charge of good men indicates that the real reason for the accident was a demoralization of the organization, and it is unfortunate that our legal system does not permit the investigation to be carried back of the direct cause, in such cases, to the real origin of the trouble. It would probably be found in this case that the prime source of trouble was the continual puttering with the details of design in order to make them conform with the various secret requirements of the owners' manufacturing processes. An accident from this indirect cause has been due to occur for some time, for reinforced concrete construction is particularly prone to be affected by it.

Position of Column 47

The Transportation of Mail in Chicago is now accomplished from the general post office to all of the railway stations in the freight subways of the Illinois Tunnel Co. About 1,000 tons of mail are thus handled daily, and the average reduction of time to and from all depots is about 10 minutes.

Power Plant of the Kingsland Shops of the Delaware, Lackawanna & Western R. R.

Details of the extensive shop improvements of the Delaware, Lackawanna & Western R. R., for its tidewater terminal lines and branches in New Jersey have been mentioned in The Engineering Record for March 25 and December 2, 1905. The new shop scheme embraces extensive passenger car repair and paint shops, with locomotive shops to be added, the entire works covering an area of over 8 acres, and has involved a large expenditure. The location at Kingsland, N. J., about six miles west of the Hoboken terminal, was selected as affording the most available site, convenient to the tidewater terminal, for the facilities required, and at the same time providing for future growth. The plant is close to the large freight yards of the company on the meadows adjoining the Hackensack River, but is located on high land at the westerly edge of the meadows where rock close to the surface affords excellent foundations for buildings and machinery.

The power house has been located to the rear of the shop layout, convenient to an adjoining reservoir for water supply. It is about 300 ft. from the approximate center of the group of shop buildings and immediately adjoining the mill and carpenter shop buildings in both of which large amounts of power are used. The shop layout centers, as shown in the article printed on March 25, 1905, about the passenger car repair and paint shop, 220x660 ft. in size, to the north of which is the 160x600-ft. locomotive machine and erecting shop building, now under construction, and to the south, a group of auxiliary buildings The distance through the piping and wiring tunnel to the locomotive and machine shop, the other point of heavy power consumption, is about 700 ft. The service of the power plant is confined solely to the lighting and power requirements of this shop plant, to the entire exclusion of other property of the company adjoining.

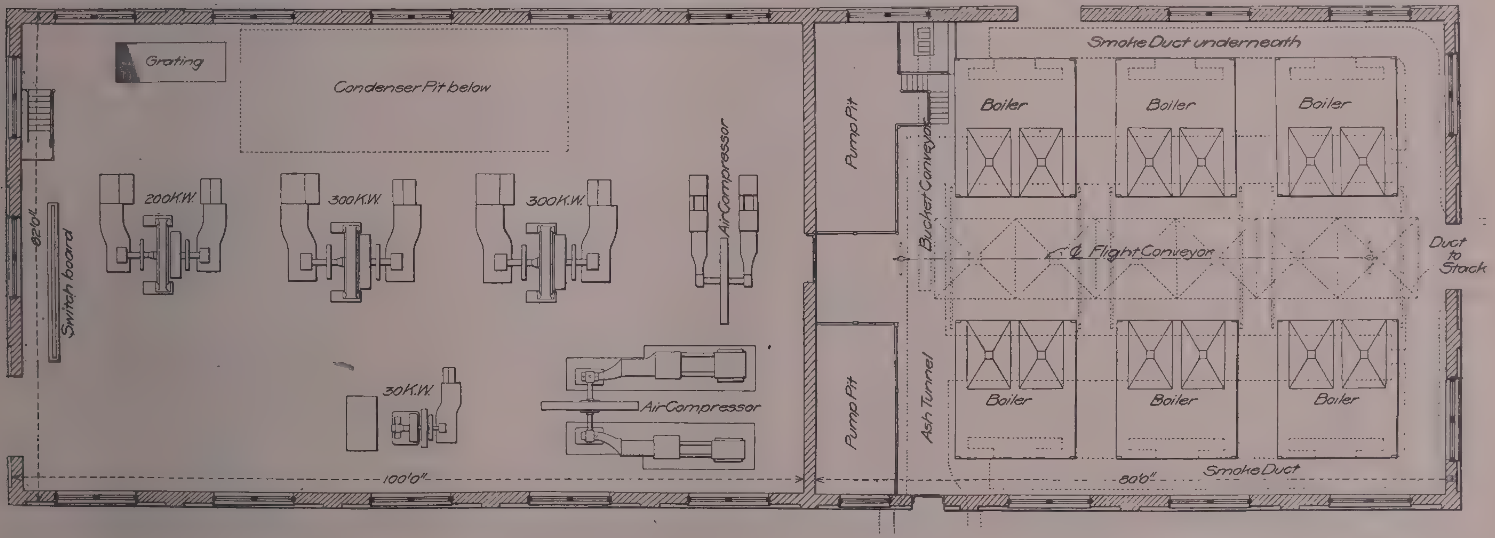
The power house is a 62x181-ft. building, divided transversely into a boiler room 80 ft. in length with a 10-ft. pump pit at one end and a 101-ft. engine room at the other. It is of brick and concrete, the walls resting on concrete footings on solid rock, which at that part of the site had to be blasted out to grade. The walls above the floor level are of pressed brick and are surmounted by steel roof trusses spaced 20 ft. center to center, carrying a concrete roof with a 12-ft. monitor. The roof covering is carried on purlins of 10-in. 25-lb. I-beams spaced 6 ft. apart and consists of 3 in. of concrete reinforced with No. 10 expanded metal, with a covering of felt paper, pitch and granulated slag. The floors are all of concrete faced with vitrified paving brick, set on edge and the joints grouted with hot asphalt, and have an interesting arrangement of underground ash pit cleaning chambers and smoke ducts underneath the boiler room. The floor in the engine room is entirely independent of the side and end walls, to prevent communication of vibration from the engines to the building. This is accomplished by supporting the ends of the transverse floor girders, which are 12-in. I-beams at 12-ft. centers and encased in concrete, on roller bearings at their side wall ends and leaving a 1-in. opening at all edges adjacent to the walls; the floor is protected at these points by a 6-in. concrete curb extending entirely around the opening and rising ½ in. above the floor line.

The boiler room is laid out for a steam generating equipment of 1,440-h.-p. capacity and without provisions for extension, this capacity being ample to operate the present passenger car shops and the locomotive shop under construction. The boilers are six in number, arranged in two rows of three each on opposite sides of the room facing a central firing floor, 15 ft. in width, and have 4-ft. 8-in. spaces at the rear for blow-off connections. The boilers are arranged in single settings with 5-ft. spaces between and ample room is left at either end of the room for passages and auxiliary equipment. The pumping machinery is accommodated at the division wall end of the room in a pit 10 ft. wide and 8¾ ft. deep, extending across the building. Above the firing floor, there are six steel coal storage bunkers in a longitudinal row, each with an independent down-spout to chute the coal to the floor for firing. The coal bunkers are each 10 ft. square and 4½ ft. deep, with pyramidal bottoms, and hold about 15 tons of coal each.

Boiler Plant.—The six boilers are of the Stirling sectional water-tube type and each has a heating surface of 2,333 sq. ft. The grate area for each boiler is 79 sq. ft., the grates being 7 ft. 3½ in. long by 5 ft. 5¼ in. wide for each of two sections which are divided by a wall extending to the arch roof over the grates. The furnaces are intended to burn sawdust and low-grade anthracite coal, so that a rectangular opening 7 in. high by 14 in. wide is provided above the two firing doors in the front of each boiler. The sawdust is conducted from the large storage bins above through metal chutes to these rectangular openings, which discharge into the furnace just under the arch or roof. The grates are similar to the standard rocking and dumping grates used on the six-wheel switch engines which burn the fine grade anthracite coal, an interesting departure from the style of plain grate usually used under stationary boilers. Each boiler is suspended from front and rear on wrought iron frames entirely independent of the masonry setting, which allows contraction and expansion to take place without straining either the boiler or the brickwork. It also allows repairs or renewals to be made to the setting without disturbing the boiler or its connections. The boilers are designed to carry 160 lb. working pressure, but were tested to 240 lb. hydraulic pressure after erection.

The products of combustion are conducted from the boilers to the stack through smoke ducts under the floor at the rear of the settings on either side of the room. These ducts which are uniformly 4x6 ft. in size, are brought together at the easterly end of the building into an 8x6-ft. flue which leads into the base of the stack outside the building. The ducts have arched roofs built into the concrete foundation of the building and are lined with 9 in. of fire brick. The connections to the boilers are 14-in. by 10-ft. downtakes at the rear of each boiler setting, which open into the smoke tunnels through arched passages, 4 ft. high by 5 ft. wide. Each branch of the smoke duct is fitted at a point near the first boiler connection with a tight-closing damper of novel construction. It is illustrated in an accompanying detail, and is of the louvre type, constructed of cast iron throughout. It consists of eight leaves, each 8½ in. wide by 4 ft. 1¾ in. long, except the top leaf which is of a special shape on the upper side to fit within the arched roof of the duct. The leaves are all heavily ribbed to prevent buckling and warping, and are supported on separate cast-iron pivot pins bolted to the ends of the leaves; this construction permits turning the pins true and also eliminates a point of possible weakness in pins cast integral. The leaves are supported in cast-iron wall plates at either side, with cored holes for the pivot pins. A cast iron operating rod for throwing the leaves is operated from the floor above by a counterweighted lever mechanism, the purpose of the counterweight being to balance the weight of the operating rod and render the throwing of the damper easy. The leaves are designed to fit the wall plates with ⅛ in. clearance at either end and to overlap each other ¾ in. at the edges, and are thus sufficiently tight when closed. The free section of the flue is 23 sq. ft., and of this but 3¼ sq. ft. is obstructed when the damper is open.

Chimney.—The stack is a 150-ft. radial brick chimney erected by the Alphons-Custodis Chimney Construction Co., and was built on a concrete sub-base which rests on solid rock and is carried up to a point 3½ ft. above ground level. Owing to the proximity of solid rock, it was found unnecessary to give the foundation the usual spread, and it was carried down with a uniform section 19 ft. square to 10 ft. below the surface to bed rock. A 2-in. air space was



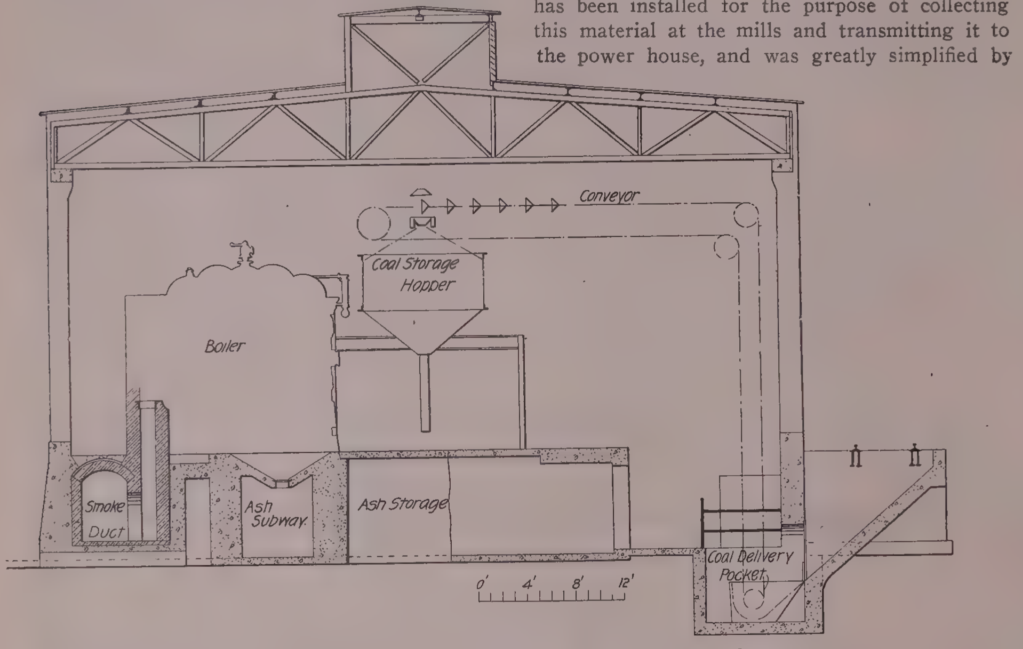
General Plan of the Kingsland Shops Power Plant of the Lackawanna R R.

provided between the lining and foundation walls for additional protection. The flue which passes under the boiler room floor was widened to the diameter of the chimney at the point of entrance, so as to reduce the depth of the opening, and to avoid a concentration of the load on the arch over the opening, five 15-in. I-beams were embedded in the concrete.

The chimney is lined the entire height and banded outside all the way up to provide against high temperature, as it was expected the fuel would be largely shavings, with which there is always a possibility of incomplete combustion resulting in secondary combustion and explosions in the flues and chimney. As the so-called "Dutch ovens" or extension-front furnaces were not provided for the boilers, it was deemed advisable to install a chimney equal to all emergencies. Instances are known where shavings have been burned in ordinary furnaces with the result that the temperatures were higher in the flues than in the furnaces. The bands are of 5/16-in. flat iron, 3½ in. wide, and are placed 6 ft. apart. They are not continuous, but are fitted with lugs at the ends and bolts for drawing them tightly together. The lining is in sections, and each section rests on a corbel from the main wall of the chimney. The chief advantages of this form of construction as compared with a continuous independent lining are that there is a sub-division of the effects of the expansion, and it is possible to renew any section without disturbing the others.

Fuel and Ash Handling.—The handling of coal from cars to the bunkers is simplified by the installation of a receiving bin underneath the railroad track adjoining the plant at one side, and elevating and distributing conveyors which deliver the coal to the bunkers. The receiving bin is a concrete structure 8 ft. in width, which extends 11 ft. out from the side of the power house under the coal receiving track at the east side, and slopes inward toward the boiler room pump pit. This bin extends in a shut-off gate at a point 10¾ ft. below the floor level, below which, in a pit 14¾ ft. deep, is located the loading boot of an elevating bucket conveyor. This conveyor raises the fuel first vertically a distance of 33 ft. and thence transversely 27 ft. to the center line of the row of coal bunkers. At the latter point the fuel is discharged on a horizontal flight conveyor which serves to distribute it to anyone of six bunkers desired. The elevating conveyor has 16x16x8-in. buckets spaced on 26-in. centers and has its vertical leg enclosed in a sheet steel casing. The flight conveyor is suspended 3 ft. above the tops of the bunkers and consists of a 14-in. steel trough 6 in. deep in which cast-iron scraper shoes, spaced 3 ft. between centers, are operated. The capacity of the coal handling system, which was installed by the Dodge Coal Storage Co., is 30 tons per hour.

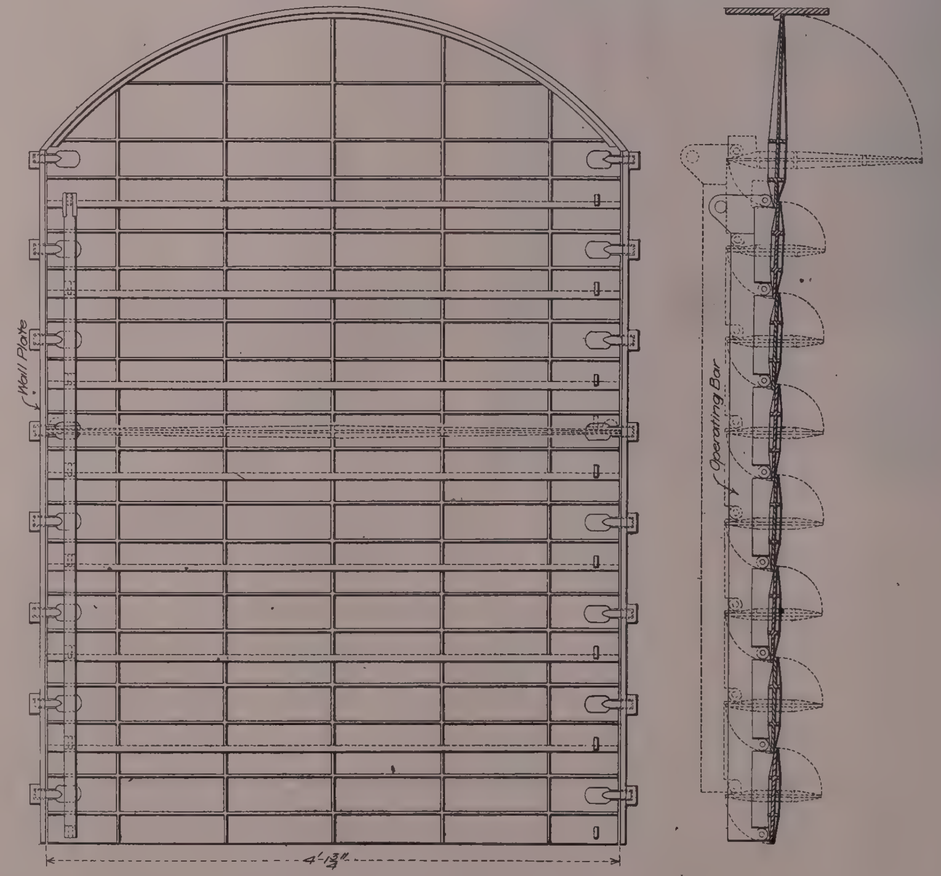
The shavings and wood waste from the woodworking departments of the shops form additional fuel supply. A central exhauster system has been installed for the purpose of collecting this material at the mills and transmitting it to the power house, and was greatly simplified by the location of the power house between and close to both the mill building of the passenger car shops and the carpentry shop of the Morris & Essex division, which has also been located at this point. Each of the buildings has a local exhauster system for gathering the shavings and waste from the machines and also from floor suction openings for removing sweepings at different points in the building, the exhaust fans for which are located on the roofs. From these centrifugal exhausters, a secondary gathering system at the power plant draws the shavings to the boiler house through overhead galvanized iron ducts, and from it separator connections are provided for discharging either into the coal storage bunkers or directly into one or two of the boiler furnaces which are fitted for wood burning. The shavings-handling systems were installed by the Allington & Curtis Co.



Cross Section though Boiler Room Showing Coal Handling System

An interesting boiler ash-pit construction has been devised with outlet gates in the ash subways for dumping the ashes directly into narrow gauge cars for removal. The ash pits, of which there are two to each boiler, are of reinforced concrete, 5½ ft. wide by 8½ ft. long, sloping downward 30 in. to outlet gates at the middle. The inclined concrete side walls are reinforced by No. 10 expanded metal, the reinforcement being continuous from the 6-in. channels forming the 12-in. square opening at the base to T-rail reinforcements at the upper edges. The outlet gates are of an undercut pattern, supported by lugs riveted to the channel members in the opening and are operated by release levers of simple construction which are set to one side of the subway so as to clear the ash cars and also be convenient to the operator. The gates are held normally in closed positions by a loop tying the operating handles together as shown in the accompanying detail drawings.

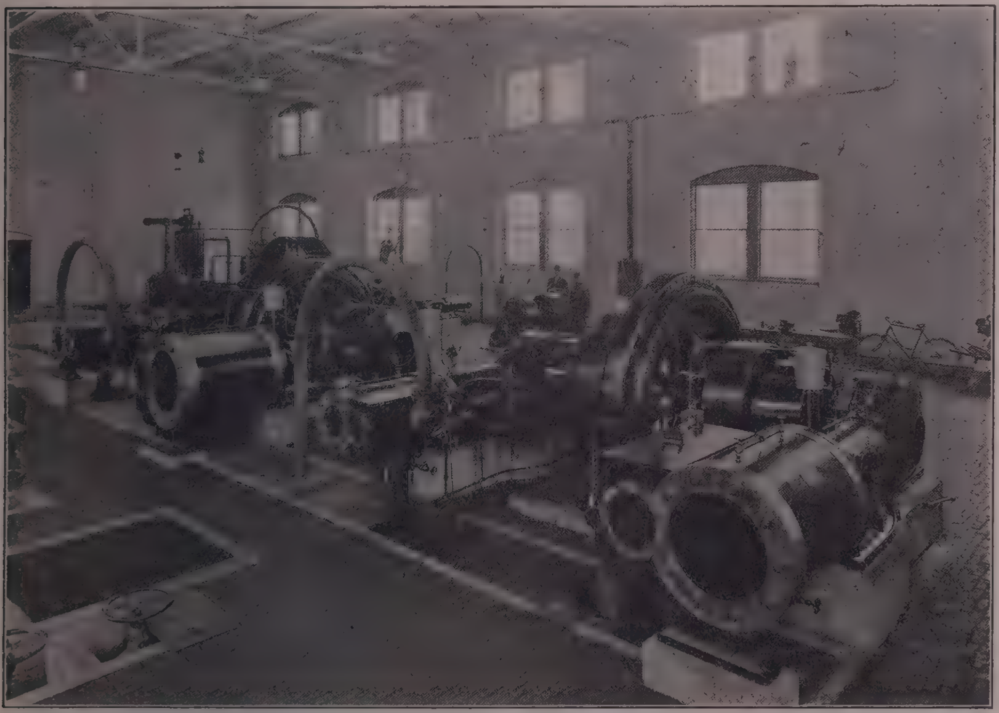
The handling of ashes is rendered unusually convenient by an arrangement of subways with industrial railway tracks underneath the boiler ash pits, by means of which the ashes may be dumped directly into the cars, quenched and then run into a branch extending outside the building, above which is an electrically operated telpher hoist for raising the ashes to the surface for removal. The subways consist, as shown in the accompanying drawings, of two 6x7-ft. tunnels, one underneath each row of boiler ash pits, which join at their westerly ends with a 5x7-ft. transverse tunnel leading outside the south wall of the boiler room to an open section over which



Details of Louvre Smoke-Duct Damper.

is located the telpher hoist. The industrial track is of 26-in. gauge, and at the junctions of the tracks in the two longitudinal and the transverse subways, small cast-iron turntables are located. The cars are of steel, fitted with inclined racks to hold closed a type of automatic dumping bucket into which the ashes are discharged from the ash pits. These, when run outside and under the telpher, are hoisted and thence traversed by the telpher over a railroad car on an adjoining side track for dumping, which is accomplished by hoisting slightly above the traversing position to a tripping block, which opens the bucket automatically.

An interesting provision is made for the ventilation of these subways for the removal of dust when ashes are being dumped and of the steam formed in quenching them. This consists of vent openings at the easterly ends of the longitudinal subways which connect into the underground smoke ducts leading to the base of the stack at that end of the building. These vent openings are furnace registers, with dampers for opening and closing, which form openings 2 ft. square into the stack flue. When these are opened a strong draft is induced by the stack through the subways, which effectively clears them. These openings will have little effect on the chimney draft, as they will be used only during periods of removal of ashes and at all other times will be kept closed. Provisions for the drainage of the tunnel are made by grading toward the outside opening, to which all leakage and quenching water are drained; a catchbasin under the center of the ash hoist opening, with a pocket 3 ft. below the sewer level, serves to retain ashes and sediment and thus prevent clogging the sewer.



Engine Room of the Kingsland Shops Power Plant.

The ash hoist is an electrically operated telpher having a total lift of 24 ft. and traverse of 24 ft. and is operated from controllers located within the boiler room, one for the hoisting and the other for the traversing operations. It is of the usual construction of the Dodge Coal Storage Co., but is of small size, having a capacity of one ton. The telpher runway consists of a 50-lb. T-rail carried on a 12-in. I-beam with 12-in. channel cover, one end of which is built into the wall of the building and the other supported on an 8-in. steel post, 22 ft. from the wall of the building so as to span the opening and an adjoining track. The telpher rail is 22 ft. above the rail level of the adjoining yard and is offset 26½ in. from the center line of the subway opening, which is 7¾x10 ft. in size. In this portion of the subway, the industrial track has a turnout for passing cars, one of which tracks is under the center line of the telpher runway for convenience of hoisting out ashes, while the other serves for returning empty cars back into the building, the turnouts being fitted with spring switches which throw all loaded cars to the telpher side of the opening and cars returning to the opposite side.

Water Supply.—For the boiler feed and general water service, a private water supply system has been established at the shops which includes four driven wells fitted with air lifts and a large concrete storage reservoir. Two wells are on the shop grounds and the other two on the right-of-way, about 1,000 ft. from the grounds. The wells were driven through rock, one to a depth of 315 ft. and the others to 325 ft. The water is of good quality, well adapted for boiler feeding. The wells are operated by American air lifts, supplied with compressed air from the shop air distribution system, and discharge at present into a temporary basin, from which the boiler feed and fire pump suction connections are taken. Permanent storage is provided by a 2,000,000-gal. concreted reservoir, now under construction, which is of triangular shape, and is excavated to an average depth below yard rail level of about 15 ft. It will be utilized for circulation water supply for the condensing system.

Two water service systems are installed, one a high-pressure system for fire purposes and the other a low-pressure system for general water supply. The former is supplied by a 100,000-gal. elevated steel tank 400 ft. distant from the nearest building of the shop layout. The tank is carried on a steel tower, the base of which is about 6 ft. above the shop floor level, the outlet being 100 ft. above the base. The low-pressure service system is supplied by a 60,000-gal. steel tank, alongside of the fire tank but with the outlet only 24 ft. above the base, making the high tank 106 ft. and the low tank 30 ft. above shop floor levels, respectively. Delivery is made to the latter by duplex steam pumps in the power house, which draw from the wells, while the high tank is filled by one of the three pumps that are utilized for boiler feeding.

The boiler feed system has three pumps, two primary heaters and an open heater, and a duplicate system of bronze feed piping. The three boiler feed pumps are of the duplex outside-packed plunger type built by the Scranton Steam Pump Co., and have 12x8x12-in. cylinders. They are so piped that any two can be used at the same time, leaving one in reserve; one is used for hot water and another for cold water. The two primary heaters are 24 in. by 8 ft. closed heaters built by the Whitlock Coil Pipe Co., and each has 150 sq. ft. of copper pipe surface. They are connected into horizontal sections of the exhaust line near the condenser inlets and have eccentric heads to avoid pocketing and the necessity of drainage connections. The primary heaters serve for initial heating only of the cold feed water, which is then passed to the open heater for further heating. The open-feed heater is of the Cochrane purifier type, having an oil separator of the single plate, impact baffle type for a 14-in. pipe and a water seal to discharge the separated oil from the exhaust steam out to waste. The heater is supplied with the exhaust steam from the pumps and auxiliaries, and has a heating capacity of 52,000 lb. of water per hour. The feed-piping connections are so arranged that all jacket circulation and intercooler water from the air compressors is discharged into the open heater and the remainder necessary is delivered from the water service mains through the primary heaters as required. It is delivered from the open heater to the boilers through either of two 4-in. duplicate feed mains, which are carried in the open space underneath the boiler room floor. These mains are protected from excess pressure by Ashton nickel-seated water relief valves, set at 25 lb. above boiler pressure. Each of these mains has a valved branch to each boiler, the two branches to each of the latter joining near the steam drum into a common feed pipe with check valve and secondary stop valve.

The blow-off piping is a simple system of 3-in. mains at the rear of each row of boilers, with 2½-in. branches to the mud drums of each of the boilers. It is standard flanged cast iron pipe and is carried along the ceiling of the basement, the branch connections passing from the boilers through the floor. The blow-off valves are Mowry extra heavy valves and are installed in duplicate to prevent leakage. The system discharges into a blow-off tank below the surface of the ground outside of the building and arranged with an overflow to the sewer. Into this system is also run a drip connection from the exhaust head above the roof, from the riser connection to the exhaust head, and from the dirty drip system from the engine cylinders.

Steam Piping.—The steam piping systems have a simple layout, but have been designed with special reference to reliability under all conditions of service. The high-pressure system starts in a 10-in. ring main which surrounds the entire boiler room and has branches to the nozzles of each boiler. This main is sectionalized by gate cut-off valves at four points, by means of which the station may be operated in a number of combinations. Two of the section valves are located at the point of entrance of the ring main into the engine room basement, between which the supply mains to the steam using machinery are taken off, while the other two sectionalizing valves are so placed at either side of the boiler room that each of the three sections made thereby has feed connections from two of the boiler units. This arrangement permits cutting out any section of the ring main in the boiler room without interfering with the remainder of the system. The boiler branches are all 6-in. long radius bends with a gate valve at both the boiler nozzles and at the main.

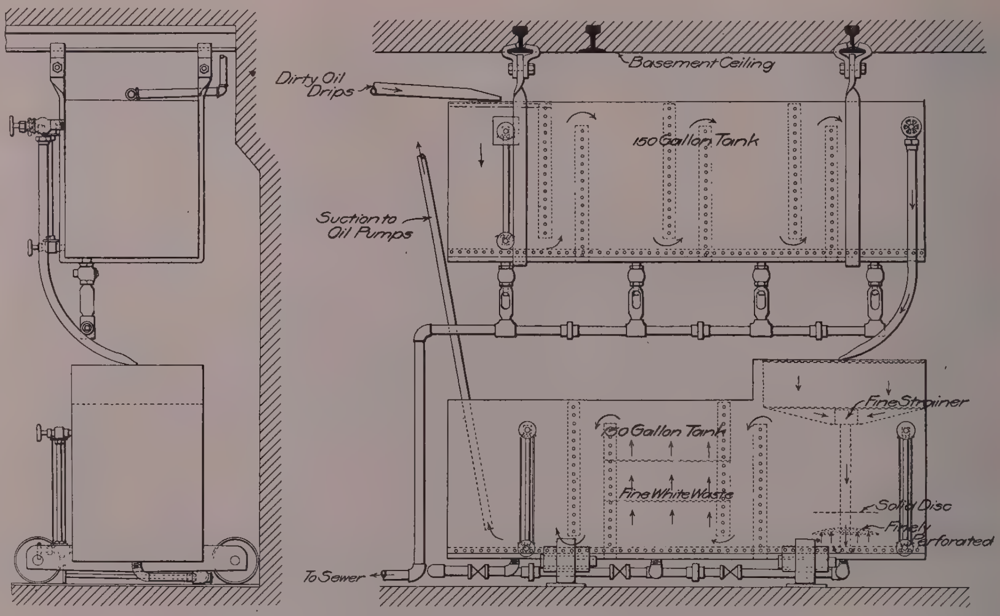
The delivery connections in the engine room basement consist of a 10-in. branch at one side from which steam is supplied to three generating units, a 6-in. branch on the opposite side which supplies the larger air compressor and the steam-driven exciter unit, and a short 5-in. branch near the middle connecting with the smaller air compressor. These branch connections to the engines are all made from tee fittings with downward outlets, for the purpose of freely draining condensation from the mains. This condensation is intercepted by separators, of which one is provided at each engine throttle except in the case of the large air compressor, where one separator serves both the compressor and exciter engines. These separators are Cochrane vertical baffle separators of specially heavy construction of ½-in. steel plate and each is mounted rigidly upon two 8-in. I-beams, embedded in the foundations, to prevent vibration being transmitted from the engine to the steam main. These separators are in fact depended upon for the drainage for the high-pressure system, the only other drainage points provided being at the ells, where the ring main drops to pass through the division wall to the engine room basement. These drip pockets and the five separators are drained by a 1¼-in. drip system leading to an Albany return trap, which returns the condensation to the boilers automatically.

The ring main in the boiler room is supported by an interesting form of adjustable hanger illustrated in an accompanying detail. It consists of a cast-iron bracket 26x30-in. in size, bolted to the outer wall, in which an adjustable roller support is fitted. The roller is of cast iron, shaped to accommodate the pipe carried, and is supported in a forged yoke with screw stem. By means of double nuts this stem can be raised or lowered to line the pipe as desired. This stem fits into a slotted hole in the bracket which admits of about 7 in. transverse adjustment of the yoke for horizontal alignment. Where the ring main crosses over to drop and enter the engine room basement, it is suspended, as in the engine room basement, by a more simple form of suspension hanger, consisting of adjusting blocks carried by the roof trusses.

For supplying steam to the pumps and auxiliary equipment of the plant, there is a 6-in. auxiliary main in the boiler room which is also of the ring type. It is looped over the fronts of either row of boilers with 4-in. connections to the steam nozzle of each, and extends to either corner of the room at the division wall end with connection to the pumps. The boiler branches are short direct connections to a tee fitted above the 6-in. nozzles and are connected through two 4-in. gate valves in tandem. This main is supported throughout by suspension hangers from the steelwork of the building. The supply connections made to it are a 2½-in. branch to each of the three feed pumps, a 4-in. branch to supply two condenser pumps and a steam turbine pump unit, and a 5-in. branch to a live steam water heater for the hot water heating system of the shop plant. All of the high-pressure piping is of extra heavy pipe supplied by Best & Co., of Pittsburg, with rolled steel flanges of the Van Stone type on all lines 6-in. in size or over. Copper gaskets are used throughout.

A drainage system has been carefully planned for the return of condensation to the boilers from the steam separators and auxiliary heater for the hot-water heating system. The various drainage systems discharge to receivers in the condenser pit, from which the condensation is raised by the steam pressure to three Albany traps in the roof monitor over the boiler room. The traps are of the return type and are so connected that any one can be used in connection with either one of the two condensation receivers in the basement. For the equalizer connection to operate the traps, a 1½-in. steam line is extended over the boilers in a loop, with connections to the safety valve outlet of each boiler, which line is reserved entirely for the purpose of equalizing pressure in the traps, there being no other connection allowed except to the Locke damper regulator by which the chimney draft is controlled. The three traps discharge condensation through a 3-in. line which has connections to the mud drums of the boilers.

Exhaust Piping.—There are two main systems of exhaust piping, providing for operation of the generating units and air compressors either condensing or with exhaust to atmosphere, and in addition an auxiliary system for the exciter engine and the various pumps. The former has an unusual arrangement of connections to permit operating any one of the main engine or compressor units condensing in connection with the exhaust steam water heater of the hot water heating system, and to permit changes from one service to the other without interference with the condensing system. The connections include two lines of exhaust main, one of 16-in. and the other of 18-in. pipe, into each of which a branch is taken from every engine. The piping has extra large connections, the exhaust branches from the generating units being 12 and 14 in. and that from the two air compressors a 12-in. line. The 18-in. main extends to the rear to an atmospheric riser with exhaust head for relief to the atmosphere if necessary, there being an 18-in. Kieley relief valve near the base of the riser. Below this relief valve is a 16-in. branch connection to the hot-water heater, which is a closed condenser of the feed-water heater type, 6 ft. in diameter by 20 ft. high. The 16-in. vacuum main is connected to the two primary water heaters of the feed water system and to the surface condenser units as shown. The arrangement of connections is such that none of the machines can exhaust into the condensers without serving one of the primary heaters, and either condenser may be used as desired. For relief of this system from back pressure there is a 16-in. Kieley relief valve connected at one end between this line and the other 18-in. main, which extends to the atmospheric outlet. There is also a connection from the hot-water heater to this 16-in. condenser main so that, if desired, part or all of the engines may be operated in connection with the hot-water heater and also condensing.



Details of the Oil Filter System.

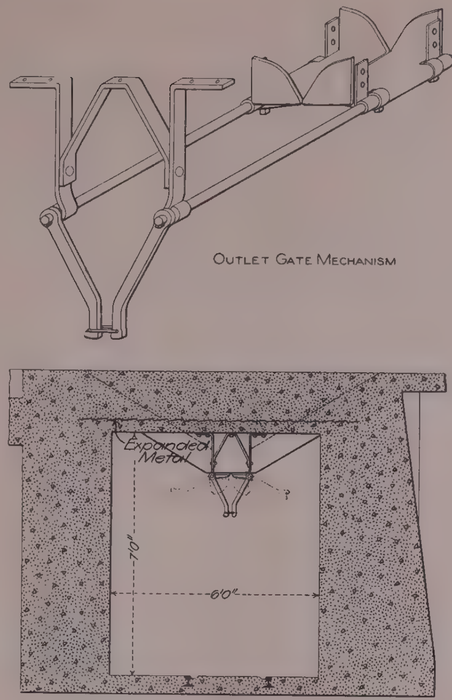
For the exciter engine, pumps and other auxiliary equipment there is an auxiliary exhaust system having a 5-in. main at one side of the pump pit in the boiler room to which 3-in. branches are taken from the feed pumps, a 4-in. branch from the exciter engine, a 3-in. branch from the steam turbine pumping unit and the condenser pumps. At a middle point of this main there is a 10-in. branch taken to the open feed-water heater and alongside is a 6-in. atmospheric exhaust riser to a McDaniels exhaust head above the roof; this riser is fitted with a Kieley back pressure valve and has connected to it, above the relief valve, a 6-in. vent from the top of the open heater.

Power Units.—The engine equipment consists of a 200-kw. and a 300-kw. generating unit, a steam-driven and a motor-driven exciter unit, and two large air compressors for the shop compressed air service. There is a foundation provided for an additional 300-kw. unit which was not installed at first but now that the locomotive machine and erecting shop is approaching completion, will soon be put in place. The electrical generating units all consist of horizontal cross-compound Buckeye engines with multipolar generators mounted on the shaft. Both the 200-kw. and 300-kw. units are designed for operation at 225 r.p.m. with a steam pressure of 160 lb., the cylinders being fitted with main and cut-off valves of the cylindrical balanced type. The smaller units has 13 and 25x18-in. cylinders and has a non-condensing rating of 380 h.-p. The larger unit has 16½x30½x18-in. cylinders and operating at rated speed and initial steam pressure and a 26-in. vacuum, has a capacity of 460 h.-p. Both units have an economical range of 20 per cent. above and below rating and an ultimate overload capacity of 45 per cent. above rating, and when working at rated capacity are guaranteed not to consume over 16 lb. of dry steam per i.h.p. per hour for the larger units and 20 lb. of dry steam per i.h.p. per hour for the smaller. They are fitted with shaft governors and are capable of regulating within a maximum variation of 2 per cent. from normal speed under very wide changes of load, but the regulation is dampened to 3 per cent. on account of the varying loads carried.

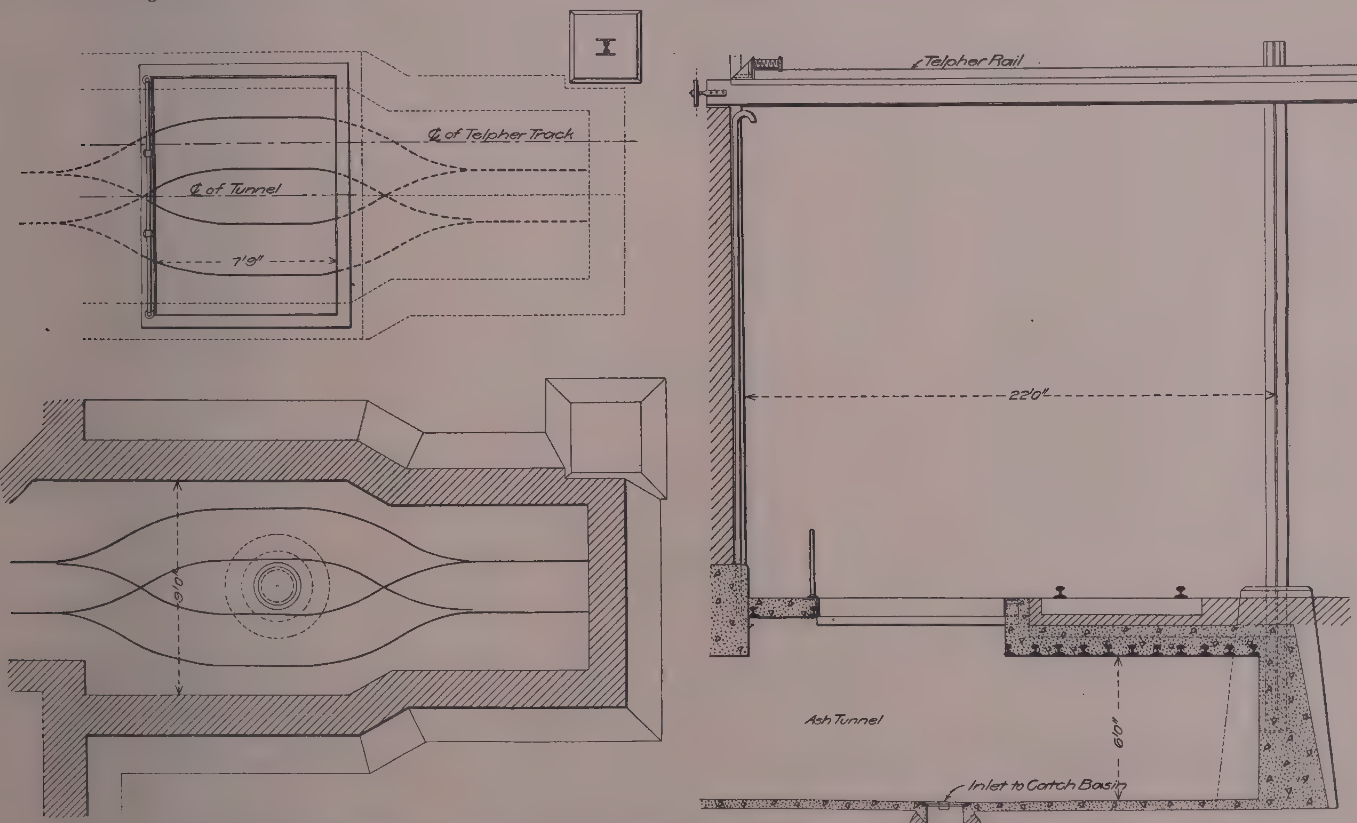
The exciter unit is of 30 kw. capacity, consisting of a simple horizontal automatic cut-off Buckeye engine direct connected to a multipolar generator for direct-current supply and exciting purposes. It has a 7¾x12-in. cylinder and operates at 300 r.p.m., its rating when operating non-condensing being 53 h.-p. Its economical range and speed regulation are similar to those of the larger units, and it has a guaranteed steam consumption when operating at rated capacity of not over 30 lb. to dry steam per i.h.p. per hour. The exciter engine is operated non-condensing, the steam from it being utilized in the open heater.

The air compressor equipment consists of two two-stage units with intercoolers, one with a capacity of 1960 cu. ft. and the other 1,100 cu. ft. of free air per minute. The larger unit is an Ingersoll-Sergeant class G cross-compound compressor with 20 and 32-in. steam cylinders and 30¼ and 18¼-in. air cylinders, with a common stroke of 24 in. The smaller unit is a New York-Franklin two-stage duplex machine having 16 and 23-in. air cylinders and 14-in. steam cylinders with a common stroke of 18 in. These compressors both deliver to a large storage receiver and thence to the shop distribution system. They are operated under automatic governor control, actuated by the air pressure and are fitted with relief valves for protection from excess pressure.

Auxiliaries.—The condensing equipment is of the surface type and was specially designed for the conditions at this plant. It is located in an extensive pit in the engine room basement at the rear of the engine foundations and consists of a compound duplex air and circulating pump with attached condenser chamber. The latter contains 1,200 sq. ft. of tube surface with a maximum condensing capacity of 10,000 lb. of steam per hour. The pump has 9-in. steam and 12-in. air and circulating cylinders and a 10-in. stroke, and is brass fitted throughout. Space is provided for an additional condensing unit of similar capacity, to be installed when required. The condenser injection and discharge connections are two lines of bell and spigot cast iron pipe which extend through a tunnel to the carpenter shop and thence to the water storage reservoir beyond. One of these, a 14-in. line, serves for the suction connection and through the other, a 10-in. line, the discharge is returned to the reservoir. The condensation from the condenser is delivered into the 10-in. discharge line, there being no hot well provided for this purpose.



Details of Ash Subway and Ash Hopper Outlets.



The Ash Subway Extension, with Open Hatchway and Telpher Hoist Runway Above.

An interesting gravity system has been installed to deliver oil to the journal bearings of the various engines, and also a receiving and filtering system for reclaiming the oil used. There is an overhead oil reservoir in the engine room, having a capacity sufficient for a three days' run of all the machinery in the power plant. From it gravity piping extends to the journals of all machinery. The tank is located in the roof monitor so that a head exists in the distributing pipes sufficient to flush out the bearings and clean out the supply pipes if clogged, and thus insure a reliable feed. The oil after passing through the journals is collected by the engine drip pans and returned to a large filter in the basement and thence to a storage tank from which it is pumped back to the elevated reservoir.

Both the filter and storage tanks are rectangular steel plate tanks 20x71 in. in size, the filter tank being suspended from the floorbeams of the basement 4 ft. above the floor line while the storage tank rests on the floor directly underneath the filter tank. The latter is mounted on a wheel carriage so that it may be withdrawn from beneath the upper tank for cleaning.

The upper tank serves essentially for the separation of entrained water from the oil and also the deposition of sediment, being fitted with three sets of intercepting baffles, as shown in the accompanying detail drawing. The arrangement is such as to cause the dirty oil to pass three times between the zigzag baffles, thus causing the water to pass to the further end of the tank for ease of removal. The water and sediment are drawn off through a series of drain connections beneath the tank which are fitted with sight outlets to enable the condition of the discharge to be noted. The final outlet for drawing the clear oil off to the filter and storage tank below is connected at a point 20 in. above the bottom of the tank and drops to the initial filter basket of the lower tank. This consists of a raised section at one end of the tank, filled with fine white waste, and a fine strainer through which the oil passes down to the bottom of the tank; the oil passes into the tank through a 1½-in. pipe with a perforated shield at the base, as shown in the drawing, and thence to the other end through two sets of intercepting baffles, similar to those in the upper tank. In the middle partition there is another filter bed of fine white waste for a secondary filtering to insure entire freedom from foreign matter. This tank is also fitted with drainage connections for drawing off sludge and sediment from the bottom.

From the further end of the lower tank the oil is taken to the pump used for raising it to the elevated reservoir. It is a 3x2x3-in. duplex steam pump, of sufficient capacity to raise in a very few minutes enough oil for a 24 hours' run of the plant. This oiling system was designed in the office of the mechanical engineer of the railroad company and, while simple, has proved by the test of time and service to be very satisfactory. A similar system has been in service at the power plant of the Keyser Valley car shops of this road, near Scranton, Pa., for nearly two years with equally good results.

Electrical Equipment.—The electrical generating equipment consists of three-phase alternating-current machinery operating at 480 volts and 60 cycles, the shop power system utilizing induction motors for all purposes except the crane service. As above stated, the generating units are of 200-kw. and 300-kw. capacity, of the slow-speed engine-type, built by the Crocker-Wheeler Co., direct-connected to the engine shaft. A third unit, of 300 kw. capacity, is being installed, which will be exactly similar to the present larger unit. These machines have closed armature slot construction and solid pole shoes to adapt them particularly for parallel operation, and are guaranteed to carry 50 per cent. overloads two hours without dangerous rise of temperature. The exciter units consist of two 30-kw. Crocker-Wheeler generators, both compound-wound direct-current, 125-volt machines. One is driven by a 50-h.-p. induction motor operated from the main alternators. A special function of the steam-driven exciter unit is for service in starting the large generator units. After they have been placed in operation the excitation current may be furnished by the motor-driven exciter and the steam-driven exciter shut down if desired. For the supply of such direct current as is required for the operation of the crane motors in the shops, there is a motor-generator set consisting of a six-pole, 275-volt, direct-current generator connected to a Crocker-Wheeler synchronous motor, which is operated from the main alternators. The purpose of the use of a synchronous motor instead of an induction motor is to correct to a certain extent the power factor of the system.

The electrical distribution is controlled from a handsome marble switchboard at the westerly end of the engine room, which consists of nine panels each 2 ft. wide by 7½ ft. high. The board is mounted on a substantial wooden base at one side of a cable opening in the floor, by means of which wiring connections to the generators and piping tunnel are made with great facility; this floor slot is 4 in. in width, extending the full length of the board, and has a timber curb on the front side under the board and a concrete curb floor protection at the rear. Six of the panels of the board are devoted to the generators, there being three for the main alternator units, one for each of the exciters, and one for the synchronous motor generator set. The distribution systems are controlled on the remaining three panels, one of which controls the incandescent lighting service and the other two the power circuits to the different buildings. There is in addition a small two-panel auxiliary board at one side for the control of the arc lighting circuits. The arc lamps are operated on the series-alternating system, for which there are two sets of automatic constant-current transformers with individual control panels. There are at present two arc light circuits each with 25 lamps connected.

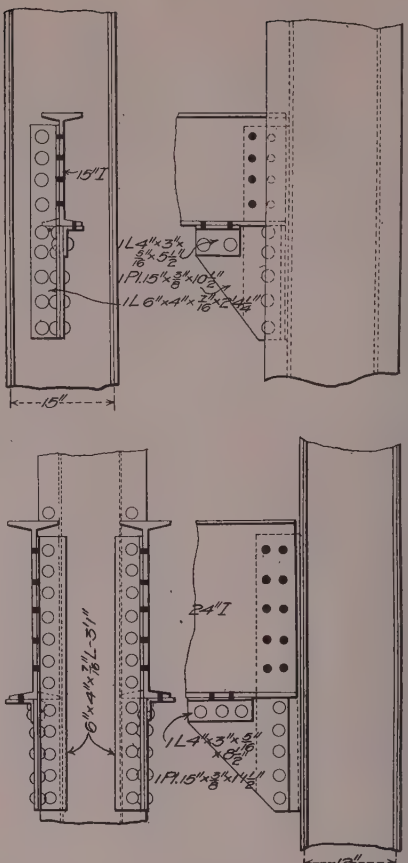
The design of the power plant is the result of a co-operation of the Engineering and Motive Power Departments of the Delaware, Lackawanna & Western R. R. The details of the power house, the coal and ash handling systems and the interesting underground smoke flue construction were worked out by the former department, under the direction of Mr. L. Bush, chief engineer and Mr. F. J. Nies, architect. The entire steam generating, electrical and air compressor equipment was designed by the Motive Power Department, under the direction of Mr. R. F. Kilpatrick, superintendent of motive power and equipment, and Mr. Jas. A. Mellon, chief draftsman. The piping systems of the plant were laid out by Evans, Almirall & Co., New York, by whom the system of hot water heating of the shop plant was designed and installed; Mr. I. N. Evans was engineer for these contractors.

The Amount of Copper in use on the lines of the American Telephone & Telegraph Co. is now in excess of 166,500 tons, representing a value of over $75,000,000.

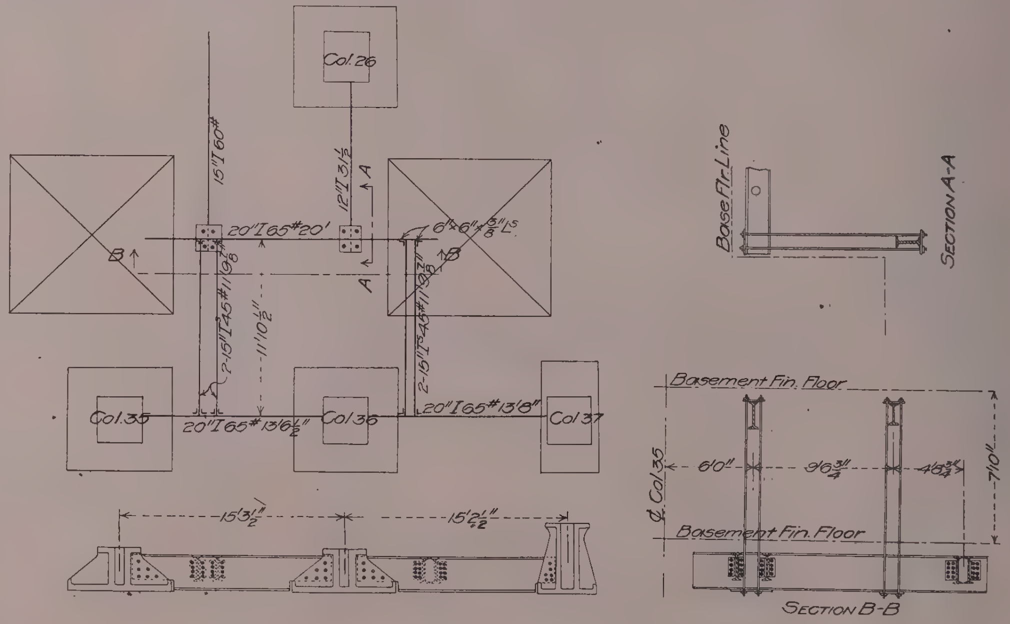
Structural Details of the Scribner Press Building.

The fifteen-story, 100x150-ft. building for the Scribner Press, 43d St. and Eighth Ave., New York, is about 175 ft. high, and is made of steel cage construction designed to carry very heavy floor loads and resist the impact and vibration of heavy printing presses on any of the floors. The floors are made of hollow tile flat arches carried on I-beams and are proportioned for a dead load of 100 lb. and a live load of 250 lb. per square foot. The girders are parallel to the stroke of the printing presses so that they will act as struts and ties, and will not be subject to lateral deflection from the movement of the machinery.

The connections between the girders and the columns are designed to develop the full value of the girder as a strut when it is fully loaded as a girder. The method of connection is shown by a detail of the support of a pair of 24-in. I-beams forming one main girder and a typical column having a closed rectangular cross-section made of two 12-in. angles and two flange cover plates. Vertical connection angles are shop-riveted to the cover plates with their outstanding flanges flush with the edge of the column and field-riveted to the web of the I-beam, the lower flange of the latter being cut to clear the angle. A solid-web kneebrace bracket is shop-riveted to the column and to the vertical connection angle, and projects horizontally far enough to engage the bottom flange of the girder with two field rivets through the bracket flange angle. These connections distribute the loads symmetrically on the column, providing a minimum number of field rivets, all of them easily accessible for driving, and reduce all rivet stress to direct shear, thus securing advantageous conditions both in service and erection. Where single 15-in. I-beams are used, they are located on the center lines of the columns and are connected to the channel webs with vertical angles and knee-brace brackets similar to those above described, but varying in dimensions. In all cases there is ¼ in. clearance allowed between the columns and the ends of the I-beams.



Beams and Girder Connections to Columns



Anchorage of Basement Floor Reinforcement.

The construction in the rear of the building is somewhat peculiar because the walls of the first, second and third stories project about 10 ft., about 6½ ft. and about 3½ ft. respectively beyond the rear wall of the upper stories. The corresponding projections of the second and third floors are carried by the columns in the plane of the wall of the upper stories. The girders cantilever beyond the columns and have their extremities stiffened by knee-braces. The 3-ft. spaces between the ends of the floor girders and the wall of the story below is covered by an inclined skylight, which, with the glazed area of the wall itself, enables this construction to give an exceptionally good light in the building.

The height of the building is virtually increased one story by the construction of a studio 17 ft. high, which has angle iron framework and covers about 90 per cent. of the roof area. In the rear of the building, where the excavation was about 20 ft. below the curb, the concrete cellar floor and the concrete footings for the column bases were made directly on the hard rock surface. In the front part of the building, the excavation for the boiler-room was carried down to a depth of about 35 ft. below the curb and encountered so much soft rock and water that it was necessary for the piers to be sunk still farther in open pits for the concrete piers supporting the columns at the floor level.

The ground water rose in the pits to a level of about 30 ft. below the curb and it was considered necessary to provide for a considerable upward pressure on the 20-in. waterproofed concrete floor. This was done by reinforcing the continuous concrete slab with a system of 10-in., 12-in. and 15-in. horizontal I-beams, web-connected to 15 and 20-in. I-beam girders. The girders have their flanges cut at the ends to clear the webs of the cast-iron column pedestals to which they are secured with ¾-in. bolts engaging round holes at one end and slotted holes at the other, provided to allow for slight inaccuracies of length or spacing. In some cases one end of the girder was secured in this way and the other was carried under the foundation piers of heavy machines.

In one case a 12-in. reinforcement beam was located in the basement floor at a level about 8 ft. above the boiler-room floor. One end of this beam was connected to a column base at the upper level, but the other end would not reach to the adjacent column and was anchored down by two pairs of vertical ¾-in. rods engaging a saddle plate on its top flange and a corresponding bearing plate on the lower flange of a 20-in. girder at right angles to it in the boiler-room floor, but projecting at both ends under machinery foundations heavy enough to resist all the upward reaction.

Cast-iron pedestals for the columns are made with base plates up to 57 in. square and 3½ in. thick reinforced by 2½-in. vertical webs on the edges. The 2¾-in. cap plates are connected to them with three transverse and two longitudinal vertical webs besides diagonal webs extending to each corner and reinforced at their center points. The pedestals are seated directly on the concrete piers or footings except those for the wall columns, where they were placed on I-beam grillages in order to distribute the loads over long and narrow footings.

The J. B. & J. M. Cornell Co. was the contractor for the structural steel, and the details and designs were made under the direction of Mr. A. E. Roberts, of its staff.

A Limit on Passenger Train Speeds has been set by the management of the Chicago, Burlington & Quincy Ry. by a recent order forbidding excessive speeds in making up time or maintaining schedules, it having been decided that the safety and comfort of the passengers are more important than making time. As a guide to engineers, speed indicators have been placed on all passenger locomotives, and instructions issued ordering that time of stops at stations be reduced to a minimum.

A Warehouse Building of Composite Construction.

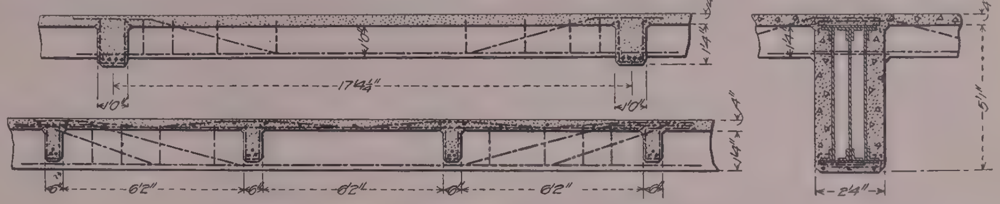
The 62x119-ft. addition to the Eagle Warehouse & Storage Company's Building, on Fulton St., Brooklyn, has just been constructed with a basement, mezzanine floor and six upper stories, the present roof being designed to serve as a floor when the building is completed to the contemplated future height of twelve stories. The building is of irregular width, varying from about 62 ft. in front to 37 ft. in the rear and is mainly of reinforced concrete, although on account of the requirement for wide unobstructed driveways and shipping space in the first story, it was deemed admissible to modify it by the introduction of heavy steel plate girders in the first floor supported on riveted steel columns about 27 ft. in height above the basement floor. Above the first story the floors and walls are carried by concrete wall columns and by cylindrical cast-iron interior columns. The front wall is of brick to harmonize with the front elevation of the adjacent old building. The other walls and floors are of reinforced concrete.

A part of the first floor used as a shipping-room was proportioned for a live load of 300 lb. per square foot. The remainder of this floor was designed for a live load of 150 lb. and all of the other floors for live loads of 120 lb. Care was taken to make the building completely fireproof by the use of concrete partitions enclosing the elevator and stair-wells, tin-covered doors, cast-iron window frames and sash glazed with wire glass, 3-in. hollow-tile partitions with angle iron frames anchored to the floor and ceiling and corrugated iron doors. All columns are filled with stone concrete and are enclosed by horizontal and vertical steel bars forming a framework reinforcing a fireproofing of concrete 2 in. thick. The steel columns are proportioned for working stresses of 16,000 lb. per square inch, which was allowed by the Building Department provided the columns were filled with concrete. The cast-iron columns are proportioned in accordance with the Building Law, but without any reduction for the successive live loads on the different floors.

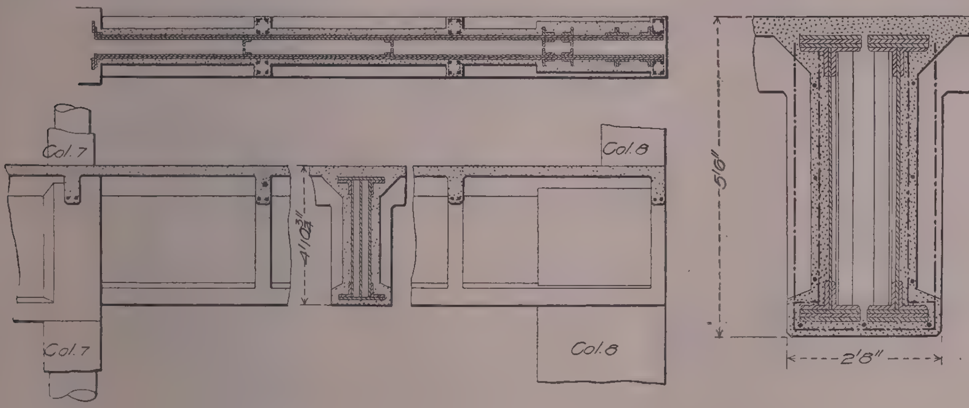
All columns have square concrete piers of varying widths up to 13½ ft. and heights up to 43 in. The bottom of the pier has vertical sides 3 in. high above which the concrete is battered uniformly to the concentric upper surface 4½ ft. square for the large piers. Each pier is reinforced with two cross tiers of 1⅛-in. Ransome bars parallel with the sides. Half of the bars extend across the full width of the pier and the other half extend about half way across the battered faces. The piers are seated about 19 ft. below the street on fine dry sand containing a small amount of clay, on which the pressure is limited to three tons per square foot.

The cast-iron pedestals are of different dimensions, corresponding to the column loads. All of them have square bases 6 in. narrower than the tops of the piers. They are made with horizontal top and bottom plates connected by a vertical cylindrical web and twelve radial webs. Their bases are set at the basement floor level on the piers, where they are carefully leveled and grouted but not anchored.

Steel columns are of ordinary construction with rectangular closed cross-section made of a pair of channels and flange cover plates and having reinforced angle bracket connections for the first floor girders. The second floor girders have their lower flanges seated on the column caps. They are of irregular lengths and depths, reaching in some cases entirely across the building and in other cases only spanning from a wall column to the single longitudinal row of intermediate columns about 17 ft. distant.



Typical Beam, Floor and Girder Construction.



Fireproofing of Box Girder and Twin Girder.

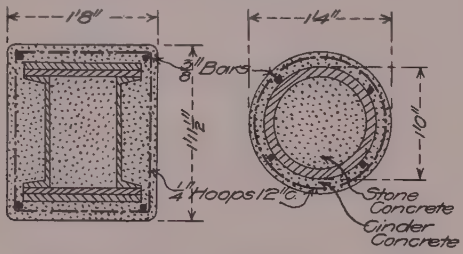
The long girders are all made in pairs set close together side by side and connected only by the bases of the cast-iron columns, which they support and which are bolted to the top flanges of both girders. The largest girders, about 37 ft. long, are made with a 54x⅝-in. web, two 6x6x¾-in. angles and one full length and one 10-ft.-13x11/16-in. cover plate in each flange. At one end these girders extend 5 ft. beyond the centers of the columns to support the outer wall. At the other end they are field-riveted to the ends of the 17-ft. girders through vertical web connection angles.

The 17-ft. girders are box girders with 48x⅜-in. webs 7¼ in. apart in the clear and have two 6x6x¾-in. angles and two full-length and two 11-ft. 30-in. cover plates for each flange. All of the girders are reinforced by double pairs of vertical web stiffener angles over the centers of the bearings and on the centers of the cast-iron columns. All girders have the webs pierced with three horizontal lines of holes about 2 ft. apart and similar holes are punched in the outstanding flanges of the vertical web stiffener angles to provide clearance for the reinforcement bars and the concrete. Some of the holes in the upper row are slotted 2 x 4 in. to receive the parallel rods in the bottoms of the concrete beams which pass through the girder.

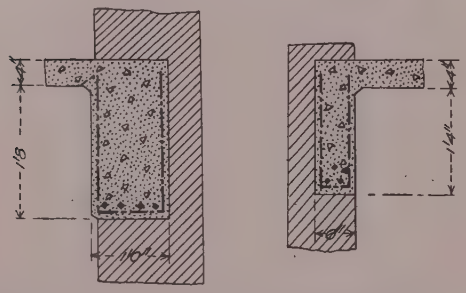
The spaces between the girder webs are not filled with concrete, but the girders are protected by a concrete jacket from 2 to 4 in. thick, which is reinforced and held in position by ¼-in. stirrup rods parallel with the webs and offset around the lower flanges and by several lines of horizontal rods, as indicated in the cross-section. The fireproofing of the box girders is substantially like that of the twin girders. In the front wall, the faces of the girders are protected by the brickwork, but the rear side and the top and bottom flanges are incased in concrete, as indicated in the cross-section. The sides of the girders are paneled by offsets where the concrete is extended beyond the face of the web to enclose the flanges of the web stiffener angles and at other points to form pilasters reaching to the bottom flange of the girders and providing bearings for the ends of the concrete floorbeams. In the rear of the building the girders are built into the concrete wall, which is extended around them to enclose the inner faces of the girder in a single continuous mass.

The cast-iron columns are generally 12 in. in diameter down to the fourth floor and 15 in. in diameter to the second floor, with thicknesses varying from 1¼ to 1¾ in. and lengths of 12½ ft. and about 13 ft. 3 in. They are of standard construction, with flange connections faced and drilled for ¾-in. connection bolts. The upper ends of the columns are special in that, above the beam and girder seats, they are made square outside with rectangular openings 5 or 6 in. wide and 14 in. deep in each face, to permit the reinforcement rods in the floorbeams and girders to pass through. The fireproofing concrete is extended 2 in. beyond the flanges and is carefully finished with beveled fillets.

The floors are carried by the wall columns and by cast-iron columns from 15 ft. 8 in. to 18 ft. 9 in. apart in three longitudinal rows from 20 ft. to 21 ft. 7½ in. apart. The columns are connected by reinforced transverse girders and longitudinal beams about 7 ft. apart. All of them are made of the standard construction indicated in the typical cross-sections. The girders in the upper floors are 12 in. wide and 16 in. deep, exclusive of the floor slab, and are reinforced with four 1⅛-in. bars. The floorbeams are 6 in. wide and 12 in. deep, reinforced by two ⅞-in. bars The floor slab, 4 in. thick, is reinforced by 5/16-in. bars 6 in. apart on centers transverse to the floorbeams and by ⅜-in. tie bars parallel to the floorbeams in alternate panels, which are made continuous across the building from front to rear.



Fireproofing and Filling for Columns

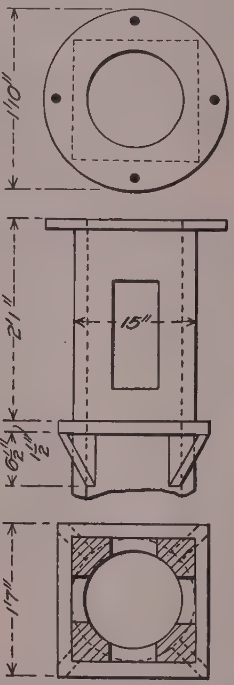


Concrete Girders Supporting Brick Walls

The floors have a cement finish made when the concrete was cast and troweled hard and smooth. They are proportioned for a 120-lb. live load, for 65-lb. dead load, and in the third floor have an allowance of 30 lb. per square foot for partition loads. In the fifth and sixth floors, the partitions are omitted and the total load is 185 lb. The seventh floor, which serves at present for a roof, carries no live load, but has an excess of dead load due to the weight of cinder concrete filled in to give the upper surface the required pitch; it is covered with felt, coal tar and gravel waterproofing.

Cast-iron columns are built into the brickwork of the front wall. In the other walls, the columns in the upper stories are of reinforced concrete with rectangular cross-sections forming pilasters projecting from the inner face of the wall. The brick wall is carried at every story by reinforced concrete girders with their outer faces 4½ in. clear of the outer face of the brickwork. The concrete walls are carried on lighter girders built in advance of the walls and having their inner faces flush with the inner face of the wall. The concrete walls are 12 in. thick for the first three stories, 10 in. for the next two, 9 in. for the next two and 8 in. for the upper story. The side walls have only a few very small windows and are reinforced uniformly with ½-in. horizontal rods about 2½ ft. apart vertically in lengths of about 26 ft., overlapping so as to be continuous from end to end of the building. There are also ½-in. vertical bars in two-story lengths 3 ft. apart on centers extending from the top to the bottom of the building.

The concrete used for filling the colunms and girders was made one part Lehigh Portland cement, 1½ parts sand and 3 parts gravel. All other concrete was made 1:3:5 with ¾-in. washed gravel. Sand and gravel were received in scow-load lots, trucked to the building and dumped to storage piles in the basement. They were wheeled to a ½-yd. Ransome mixer operated by a 30-h.-p. electric motor also driving a friction drum hoist for the automatic Ransome bucket. The bucket traveled in vertical guides and discharged its contents at the successive floors, into large hopper-bottom boxes with cast-iron gates operated by a lever at the lower end. From these boxes the concrete was distributed over the floor molds in 6-ft. Ransome dump carts.

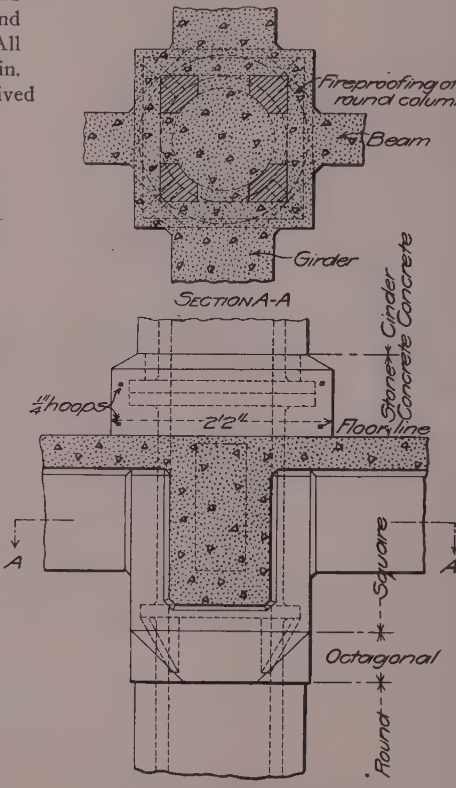


Special Top for Cast-Iron Columns

The work was done with only enough column, beam, floor and wall forms for a single story, which were successively moved from story to story as the work advanced. The concrete filling was deposited in the cast-iron columns through their open tops and in the closed steel columns through rectangular slots left for the purpose in the upper end. The steel girders were fireproofed when the second floor was concreted. Special pains were taken to make the concrete for the beams, girders and floor slabs continuous at the column connections, and all angles between the floor slab and the beams and girders as well as the lower corners of the latter were filled by corner strips placed in the molds.

The steel beams and girders were erected by the steel contractor who used for this purpose a breast derrick operated by a Mundy friction drum hoist driven with a 10-h.-p. electric motor. The cast-iron columns were hoisted by the same motor and erected with a small breast derrick by the general contractor. The cast-iron pieces were all set by Aug. 20, the structural steel columns and girders by Sept. 1, and the seventh floor was completed Nov. 24, thus making an average of ten days for the construction of each story after the time the structural steel was ready to receive the concrete. The working force consisted of about 65 men, including masons, laborers, carpenters, metal lathers and foremen. The principal quantities of materials used include 135 tons of cast-iron, 193 tons of structural steel, 2,500 cu. yd. of concrete and 142 tons of steel reinforcement.

The Turner Construction Co. was the general contractor, and Post & McCord was the sub-contractor for the structural steel work, which was fabricated at the Trenton plant of the American Bridge Co.



Column and Girder Connections

THE CONSTRUCTION OF A DEEPER CHANNEL in the Great Lakes from Chicago and Duluth to Buffalo is not approved by the Board of Engineers, U. S. A., which was appointed to examine the feasibility of providing a 22-ft. or 25-ft. channel between those cities. The present channel, authorized by Congress in 1892, is 20 to 21 ft. deep and has a minimum width of 300 ft. It was constructed at a cost of $3,340,000. In 1899 Congress ordered a 21-ft. channel to be built in the St. Mary's River at Sault Ste. Marie and in the Detroit River. The former is approaching completion and the latter is practically finished. The estimates of cost for a 22-ft. channel, made from a preliminary survey, are $7,700,000; if a 25-ft. channel be built it is estimated to cost $25,900,000. In addition to these estimates the Board states that the harbors at Chicago, Duluth and Buffalo, and intermediate cities would have to be dredged. In view of the excessive cost of all this work, the Board concurs in the reports made by district and division engineers in the opinion that a 22-ft. or a 25-ft. channel in the Great Lakes should be deferred until it is plainly shown that a safe and reliable 20-ft. channel is not equal to the needs of lake commerce.

Sand Dredging for Commercial Purposes.

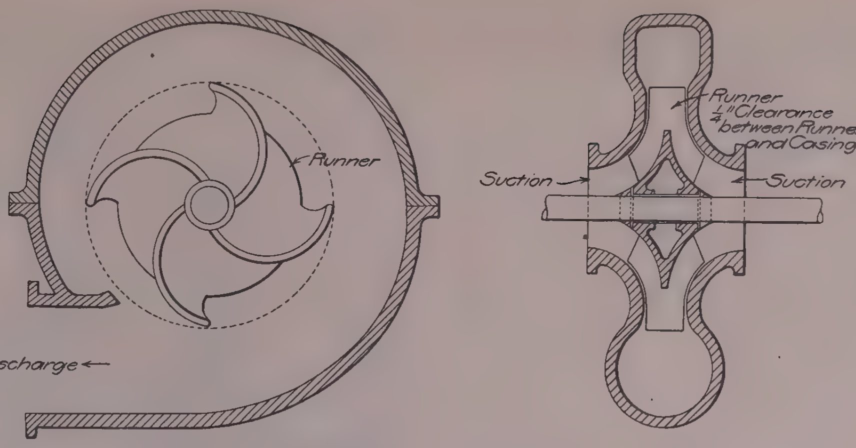
By Richard J. Donovan, Pittsburg.

One of the important industries on the Mississippi River and its tributaries is dredging sand and gravel for commercial purposes. These rivers carry an immense volume of sand, gravel and other matter which form large bars at locations where the current is checked. The annual floods also play an important part in the formation of these bars, for the high velocity of the river during these periods tends to erode the bed and side banks; when the decline sets in the load is too heavy for decreasing velocity, and the gravel and sand are rapidly deposited.

In the Ohio River, at some locations, gravel is found in large quantities with but a small percentage of sand, while in the other places the bars may be of sand entirely. In the Pittsburg district the Allegheny River is noted for its fine, clean sand and most of the sand from this district comes from this river. The sand from the Monongahela River, on the other hand, is dirty and contains injurious deposits from the numerous manufacturing plants along its banks. In the Mississippi River, as a rule, the bars are fine, fairly clean sand of quite recent deposit. These bars may be piled up to such an extent during even a medium stage, that their crests may be actually above water at low stage. An immense amount of sand and gravel is taken from the rivers annually and the development of this business has resulted in the adoption of certain types of dredges to meet the peculiar conditions existing in the various localities.

The Hydraulic Dredge.—In the dredging of recent alluvial deposits, such as occur in the Mississippi River, the centrifugal type of dredge has been found admirably adapted to the conditions. The Mississippi River Commission has made exhaustive experiments for the determination of the most efficient means for the rapid removal of sand bars, and the centrifugal dredge has been found to meet all the exacting requirements imposed in this work. The various private concerns engaged in dredging sand for commercial purposes have had the benefit of the Commission's experience in this matter, and are therefore able to conduct business on a fairly profitable basis.

The hull generally consists of the light-draft square type of heavy construction, being as a rule, housed over and arranged with suitable quarters for the crew. The dredging end of the hull is provided with strong A frame to support the suction head which projects out beyond the hull. The other end is provided with means for the proper handling and anchorage of the dredge. The dredging end is usually downstream.



General Arrangement of Pump for Dredging Sand.

The type of pump generally used is shown in the diagram. The elevation shows the runner in place in the casing, and attention is called to the volute form of the casing discharge. In the section attention is called to the close fit between the runner and casing, this being necessary so that the discharge may not leak back into the suction. The type of runner has an important bearing on the efficiency of the pump, and at present the best proportion concerning number of blades, their form, etc., seems to be unsettled, judging by recent practice. In the operation of the pump in sand or gravel dredging, the question of wear is an important one, and in the latest designs the runners are of steel and large space is provided in the discharge volute. Of course, no sharp bends must be allowed and the passages in the pump should be larger than the suction pipe so as to prevent obstruction by stones.

In many dredges, special arrangements are provided for stirring up or agitating the sand at the suction head. This is usually accomplished by directing strong jets of water into the sand, resulting in the upheaval of the latter which is caught up by the suction and drawn into the suction pipe. The discharge from the pump is arranged so that the barge moored on the side of the dredge may be conveniently filled. An open discharge trough with screen of any desired mesh in the bottom is suspended over the barge so that any stones or coarse gravel may be washed past and discharged overboard. The operator whose duty is to feed the suction head in the sand, is situated so that he can see the barge and regulate the depth of the suction head by observing the discharge mixture.

The centrifugal pump is usually driven by a compound steam engine, of either the vertical or horizontal type. As a rule, the dredges operated by the larger companies have a double equipment consisting of a pump on each side, so that barges may be loaded on both sides. A powerful hoisting engine is provided for raising the suction head, and steam power is applied to the capstans and other handling machinery. As a rule, the Mississippi River type of boiler is used. All of these commercial dredges are of the non-propulsive type, there being, however, several self-propelling dredges of this type operated by the Mississippi River Commission.

The Ladder Dredge.—In many localities, especially in the upper Ohio and Allegheny Rivers, the bars are composed of gravel with but a small percentage of sand. Such material will not flow readily to the suction opening of the hydraulic dredge, and it is very difficult to feed into the material. The pumps will handle the material readily if it can once be gotten into the suction pipe, but the wear is enormous in the pipes and pumps, and consequently the operation is not

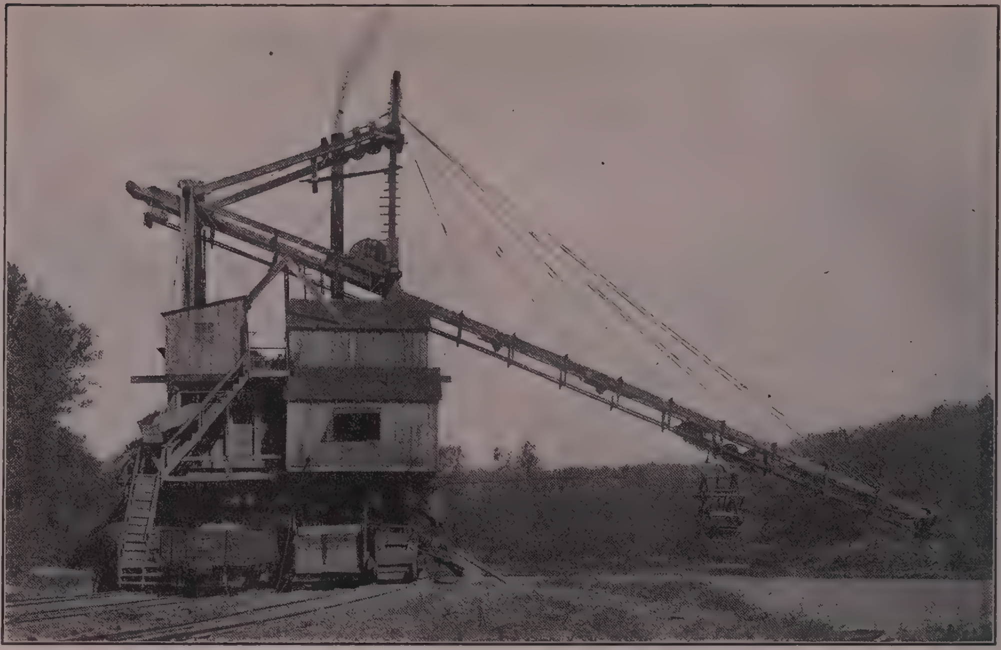
Hydraulic Dredge Used in the Sand and Gravel Industry economical. For such work, the ladder or elevator type of dredge is well adapted, and, in fact, almost all the dredges operated by the sand companies in the upper Ohio and Pittsburg districts are of this type.

The hull used in this type of dredge is of the usual square barge construction. At present, wood is the standard material used and the scantlings are such that great strength and stiffness are secured. The dredging apparatus is usually arranged on the side, since this results in cheap construction, and allows a more compact arrangement of machinery. The hull is housed over and frequently quarters are provided for the crew. Some of these dredges are self-propelling, the dredging apparatus being fitted on the side of a stern wheel river steamboat. This type is used principally in the Pittsburg district, and especially in the Allegheny River where the sand-dredging industry is carried on quite extensively.

The ladder has to be of very strong construction as the stresses incurred in this method of dredging are often very high. As a rule, in the dredges under consideration, the ladder is of timber construction with steel bracing. The members forming the ladder are connected by bracing, and at their upper end by a shaft which is carried in a frame forming part of the hull, so as to permit the ladder to revolve and change the position of the lower end.

The top "tumbler" construction has to be of great strength as it is here that motion is imparted to the conveyor system and the cutting resistance overcome. The buckets forming the conveyor system are usually of steel plates riveted together with a reinforcement at their cutting edge. They are tied together by a chain formed of steel bar links pinned at their ends so as to allow them to work around the "tumblers." Roller bearings are fitted along the ladder at intervals to insure uniform support to the train of loaded buckets. The material is cut out and carried up the ladder and dumped on the change of direction of the bucket at the top tumbler. The empty buckets are returned toward the bottom tumbler without support so that the empty train in motion hangs suspended between the top and bottom tumblers. The sand and gravel are separated by a moving screen, which is so arranged that the coarse gravel may be loaded on one side of the dredge and sand on the other.

This type of dredge when constructed of sufficient strength is able to work in any kind of soil that can be penetrated or excavated by mechanical means, it being merely a question of strength of apparatus and motive power to overcome resistance.



Grab Bucket Digger Used by Mississippi River Company

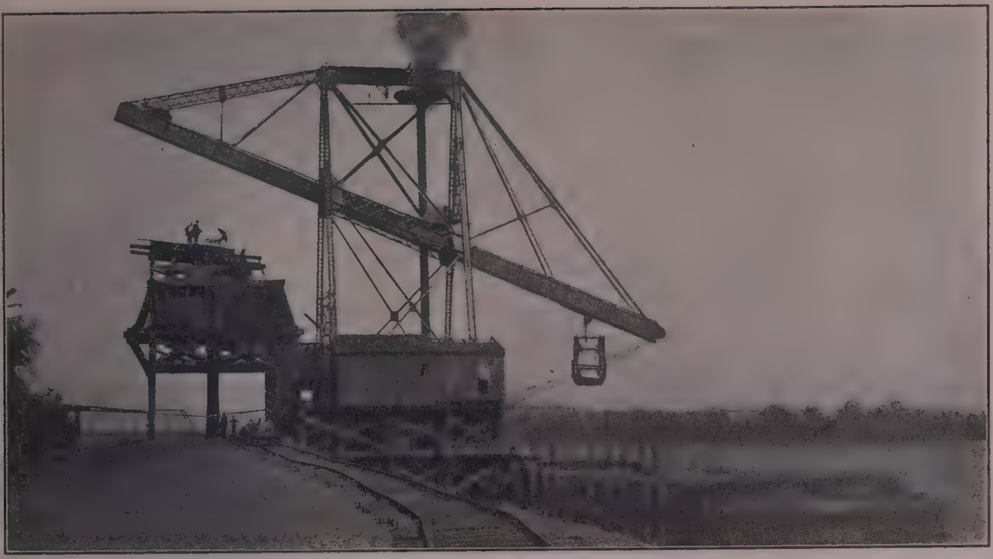
The machinery used in the non-propulsive type of dredge usually consists of boiler and engine equipment of sufficient power to operate the conveyor system and provide power for capstans, syphons, etc. The transmission of power to the ladder is generally made through chain gears, and the raising or lowering of the dredging end of the ladder is performed by a lifting device operated by power from the main engine. Steam capstans are provided for handling the barges and for changing location by using the mooring lines. In the propulsive type of ladder dredge, the boiler equipment must be of sufficient capacity to operate both the dredging and propulsive machinery. The latter consists of the usual stern wheel equipment which, of course, is entirely independent of the dredging apparatus.

The Grab Bucket Dredge.—The use of the grab bucket or clam shell in sand dredging for commercial purposes is very limited. This type in the relatively shallow rivers cannot be operated as economically as the other type discussed since its speed is much lower and the nature of its operation necessitates elaborate details for the screening of the sand or gravel. However, as illustrating a novel method of using the grab bucket attention is called to the view showing such an apparatus for digging gravel direct from the river bed. The apparatus travels along the broad gauge track on the river bank and the cars to be loaded are run under the machine. The grab bucket travels out on the overhanging arm, and on being filled, is carried back and the gravel dropped into the cars.

Method of Handling Sand.—In transporting the sand or gravel from the dredge to the unloading station, two types of carriers are used, the decked barge and the open hold barge. In the Mississippi River sand business with the centrifugal dredge, the decked type is exclusively used, while in the upper Ohio district where the elevator or ladder dredge is used, the open-hold barge is the standard type.

For the efficient operation of the centrifugal pump it is necessary that there be a large percentage of water in the sand and water mixture. On the other hand, it is necessary for the economical handling of the sand that it be as free from water as possible, besides for the practical consideration of increasing the capacity of the barge. The decked barge with cargo box has been designed to meet these conditions. The cargo box is formed by fitting side boards about 3 ft. high and arranging hoppered ends, enclosing nearly all the deck area, leaving but a small space at each end for handling lines. The barge

General View of a Grab Bucket Digger Used on the Mississippi River



Station on Mississippi River for Unloading Barges

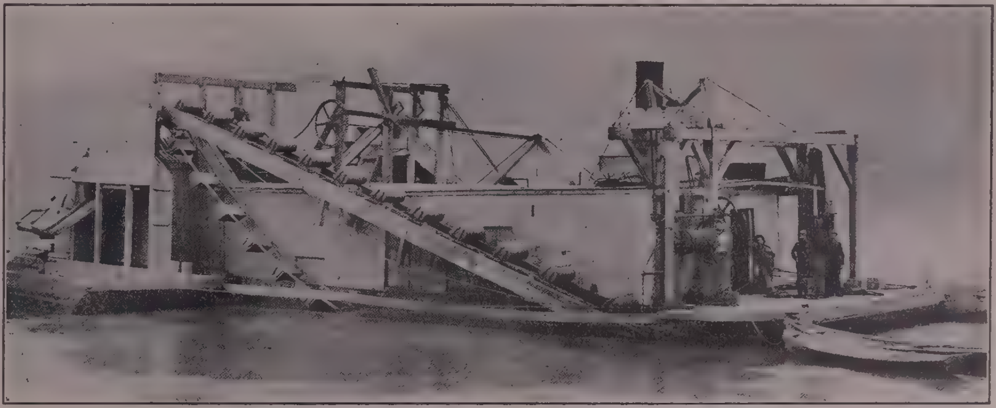
is placed alongside the dredge and the mixture of sand and water from the centrifugal pump is directed into the enclosed deck space. Freeing ports are fitted in the side boards and these are opened when sufficient sand has settled on the deck. The fine Mississippi River sand packs down very compactly and with the considerable amount of moisture remaining make a heavy cargo for the barge.

These decked barges are subject to very severe usage in the operations of handling and unloading. The large sand companies operating on the Mississippi River have installed unloading machinery of the largest capacity with corresponding weight of parts. The immense grab buckets come down on the deck with considerable shock causing heavy local stresses, so that the deck supports must be close together and of ample section. In unloading, it is also necessary at times to take out the sand very unevenly, such as removing it from one end only, or from the middle, giving rise to heavy longitudinal bending stresses, which must be provided for by continuous longitudinal bulkheads. This service tells heavily on the wooden barge and its upkeep is a matter of considerable expense and ultimate renewal after a comparatively short life.

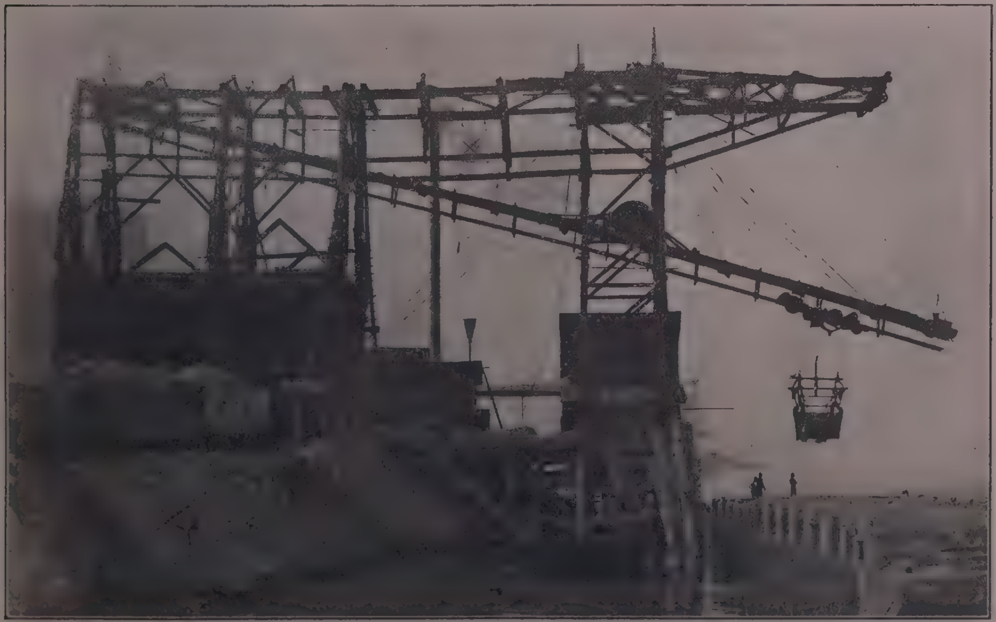
With the increasing use of steel for river boat construction, several steel decked barges have been placed in service by one of the largest sand companies on the Mississippi River. These barges are 130 ft. long, 30 ft. wide and 7½ ft. deep. A complete steel deck is fitted, and on this a wood box is arranged by fitting timber side boards tudinally so as to better care for the impact of 3 ft. high. The deck beams are framed longi- the grab bucket which is used with its cutting edges across the barge. Longitudinal strength is secured by a system of lattice girders carried full length, while the transverse strength is provided for by a system of cross trusses. The deck beams are supported at close intervals by the cross trusses, and by extra cross beams carried by the side frames. Channel sections are used to a large extent in the framing, which is spaced rather closely throughout the barge to insure strength and stiffness.

These barges have a capacity of about 400 cu. yd. of sand and draw about 6 ft. 9 in. in the loaded condition. They may have demonstrated their ability to withstand the severe service and are much more economical in operation than the wooden type. Of course the steel construction costs considerably more than the wood, but when depreciation, cost of up-keep, and interest on investment are considered, it will be seen that the steel barge, with its life triple that of the wood, is the better business proposition.

In elevator or ladder dredging, the open-hold barge is used to receive the sand or gravel. From the nature of this dredging, practically no free water is carried into the barge, and it is only necessary to provide a suitable open carrier. As a rule, these barges do not have to meet the severe conditions incidental to Mississippi River dredging. The distance they are towed is usually much less and the unloading machinery is not of such heavy type. These barges, however, are of substantial construction and are well adapted to the service. The common carrier used in the Pittsburg district is about 100 ft. long, 24 ft. in beam, and has a depth of 8 ft., and a capacity of about 175 yd.



Typical Ladder Dredge for Sand and Gravel.



Station near St. Louis for Unloading Sand and Gravel Barges

Unloading Machinery.—The usual arrangements provided for the reception of the sand from the barge consist of elevated bins situated conveniently on the river bank in connection with some type of unloading device. These bins are usually so arranged that cars or other means of conveyance may be loaded readily. In the type of unloader much diversity exists, but the illustrations show some of the most modern Mississippi River stations with their machinery. These structures are of steel. Steam and electric power are used, and manual labor is reduced to the minimum. In unloading the barges, no attempt is made to clean out the cargo box beyond the action of the grab bucket. These buckets are very heavy and at times much injury is done the deck by allowing them to descend too rapidly. The capacities of the buckets vary from 2 to 4 yd. and the speed in operation from 75 to 150 yd. per hour. At some of these plants the sand or gravel is carefully screened into different grades for various purposes. In the upper Ohio district the unloading stations are not built on such a large scale and the unloading machinery is not of such large capacity nor of such elaborate parts. Some of the unloaders consist of a boom derrick and bucket which is swung into the barge and filled by hand while others consist of a medium-size grab bucket operated by boom derrick. Storage bins are seldom used, and in many cases the bucket loads are dumped directly into wagons or cars, or else the sand is piled along the bank.

The Effect of Stripping Reservoir Sites on the Quality of Water.

One of the important technical questions recently settled in connection with the works to be built by the Board of Water Supply of New York was the desirability of stripping the site of the Ashokan impounding reservoir, an undertaking which would probably cost about $5,000,000 even if the soil removed were utilized in part in the construction of necessary dikes and embankments, and part of its expense would therefore be counterbalanced by a saving in the earthwork charges for such structures. The problem was of such magnitude and importance that Mr. J. Waldo Smith, chief engineer, submitted it with the Board's sanction to Messrs. Allen Hazen and George W. Fuller, who secured the cooperation of Mr. George C. Whipple. Their report and its appendices is a bulky document which will probably be published in book form later, but its importance is so great that the Board and Mr. Smith have consented to the publication of an abstract of it at this time.

The Ashokan reservoir will consist of two basins. The western basin will cover about 3,500 acres and hold about 48,000,000,000 gal. Its maximum depth will be about 180 ft. and its average depth 42 ft. Nearly all the 255 square miles of catchment area above the reservoir are tributary to this basin, and the water entering it will be almost entirely free from color and peaty matter, although moderately turbid at times. The eastern basin will have an area of about 4,800 acres and hold about 72,000,000,000 gal. About 25 per cent. of its area is swampy. The catchment area directly tributary to this basin is comparatively small and furnishes a water with more color and less turbidity than that in the western basin. It is proposed to furnish water exclusively from the western basin except during the very driest years, when the supply stored in the other will probably be used also.

The water from this impounding reservoir will not be delivered directly to the city, but into the Kensico distributing reservoir, holding about 50 days' supply. The problem, therefore, is not what effect stripping the Ashokan reservoir site will have on the quality of the water leaving it, but what effect this stripping will have on the water leaving the Kensico reservoir. This method of handling the water is vitally important, because tastes and odors in water, however caused, are transient phenomena. All tastes and odors in the water of Ashokan reservoir will be eliminated by natural causes before the water reaches the city, and if such tastes and odors appear in the water in the city they will be the result of conditions in the Kensico reservoir rather than the Ashokan reservoir. The report states that there is no certain evidence that the stripping of the latter reservoir will change the character of the water leaving it enough to improve the quality of the supply drawn from Kensico. For the cost of stripping the Ashokan reservoir thoroughly, it will be possible to build between the Kensico reservoir and the city works large enough to filter the entire supply from the Esopus basin, and the report states that such filtration, following aeration, will give far better water at a lower cost than can be obtained from a stripped reservoir without such aeration and filtration.

The reasons leading to this decision are given at length in the report, and the following abstract of them omits all the valuable historical references and most of the arguments on points of minor importance.

Causes of Tastes and Odors.—In arriving at conclusions as to the effect of stripping on the quality of the water it is necessary at the outset, the report states, to recognize that this subject relates particularly to bad tastes and odors, and also that there are several ways by which such tastes and odors may be eliminated. The temperature of the water in such large reservoirs varies much at different depths. For 10 or 11 months each year the bottom water will have a temperature approaching 39° Fahr.; and as the lower depths are not reached by wind action they will remain stratified and separated from the upper layers. This stratification for 6 or 7 months during the warmer portion of the year will be due, of course, to the action of the sun in causing the surface water to be warmer, and consequently lighter, than the bottom water. For several months in the winter the surface water will approach freezing temperature and then also will be lighter than the bottom water. Twice a year between these periods of stratification, once in the spring and once in the autumn, there will be a vertical circulation resulting in a thorough mixture of the water from bottom to top.

Bad tastes and odors in the water of such large storage reservoirs are produced in two general ways which are entirely different from each other and have no direct relation, as follows:

1. Bacterial Putrefaction of Bottom Water. This state of affairs results when the amount of organic matter in the stratified bottom layer of water, or in the soil of the bottom and sides of the reservoir, or in deposits or growths upon them, is so great that under the action of bacteria all of the oxygen in the water is used up in oxidizing the organic matter and converting it into simple compounds. When the bottom layers of water have their oxygen exhausted in this way the water is spoken of as "stagnant." Decomposition of the organic matter by certain kinds of bacteria continues in the absence of oxygen and produces certain changes spoken of as "putrefaction." These putrefactive changes are accompanied by bad tastes and odors due to various resulting compounds, the most conspicuous of which perhaps is sulphurreted hydrogen. These odors are spoken of as "odors of decay."

2. Deterioration of Surface Water Due to Algae and Other Growths.—Usually those forms of microscopic animal and vegetable life, which are larger than the bacteria and which produce bad tastes and odors, live and multiply in the upper layers of reservoir water when sunlight is available. The effect of stripping a reservoir affects these growths almost solely by removing the food otherwise available from the sides and bottom. Algae and protozoa are the most conspicuous of the organisms which produce odors. The odors are produced either by the growing organisms themselves or are due to oily secretions liberated by the disintegration of the organisms. They are spoken of as "odors of growth and disintegration."

Evidence from Stripped Reservoirs.—The chief fact to be learned from the practical application of reservoir stripping in Massachusetts, according to the report, is that it does not entirely or uniformly eliminate unpleasant or offensive odors from impounded surface waters. It certainly reduces these odors to a considerable extent, when compared with the results obtained under more or less comparable conditions from unstripped reservoirs, but the evidence is clear that stripping alone cannot be relied upon to produce an impounded water satisfactory as to tastes and odors at all times.

With carefully stripped reservoirs the bottom layers to a considerable depth become stagnant after a term of years, which is not long in the life of a reservoir. Messrs. Hazen and Fuller have been unable to note any signs of material growths of fungi in the bottom waters of any stagnant reservoirs in this country. While available analytical data indicate that for some 10 or 20 years the bottom layers of stripped reservoirs may not become stagnant, it is very probable that stagnation does exist in the stratum of bottom deposit and perhaps through a very thin layer of water immediately over it. And there is evidence of such stagnation at the immediate bottom in the ferrous iron in some reservoir waters which are not deep enough to have considerable stagnant layers.

In the case of stripped reservoirs, bad tastes and odors occur which are due to other organisms than blue-green algae. Thus in the Hopkinton reservoir of the Metropolitan water works, protozoa, notably Uroglena, were very abundant in the spring of 1898. Clathrocystis was very abundant in the same reservoir during the following July. Diatoms are also a factor affecting this question and the evidence indicates that stripping, even during the earlier life of the reservoir, will not prevent their development in objectionable quantities.

Effect of Stratification.—The great majority of deep reservoirs have a stagnant bottom layer during a considerable portion of each year, and the bottom water as drawn is more or less offensive and unsatisfactory.

Where the bottom and sides of reservoirs have not been grubbed, the bottom water as drawn was very unsatisfactory for the first few years and stagnation during portions of each year has continued up to the present time. The bottom conditions in such reservoirs no doubt improve slowly during a period of years, but at a rate which varies in particular cases, so that no general rule can be found. It is the general custom abroad to draw the water for use from near the surface, thus avoiding the deeply stained and foul-smelling bottom water. The water for keeping up a certain volume of stream flow below the dam is drawn from the bottom.

With reservoirs of sufficient depth which have been well grubbed and have had their vegetation cut off and burnt, stagnant bottom layers have resulted in every instance with which Messrs. Hazen and Fuller are familiar. There are one or two possible exceptions where small, deep reservoirs have been built upon areas where the vegetation was extremely sparse. This information as to stagnation of the bottom waters in well-grubbed reservoirs is largely based upon evidence as to bad odors and deep colors in the bottom waters and not on precise analytical evidence.

In deep reservoirs supplying Boston which have been stripped so as to remove all organic matter from the bottoms and sides, the bottom waters have not become stagnant for a number of years, but they subsequently developed stagnant layers, indicating that the gradual accumulation of organic matter upon the sides and bottom of these reservoirs. This accumulation is to be accounted for principally by growths which take place in the reservoir and which are not entirely removed.

In this climate there seems to be a clearly defined tendency for the accumulation of organic matter upon the bottom of all natural ponds and reservoirs. The gradual filling up with peat of the lakes left by the glacial period is to be accounted for in this way.

From the above statement of practical experiences, Messrs. Hazen and Fuller are convinced that stripped reservoirs and unstripped reservoirs ultimately approach the same conditions as to stagnation and the resulting tastes and odors. The stagnation of bottom water is so much reduced in the first year of use by removing the vegetation above the surface of the ground from the bottom and sides of reservoirs that there is no doubt about the desirability of removing it.

Effect of Stagnation Upon the Quality of Water.—There are four ways by which the quality of water is unfavorably affected by stagnation in the bottom layer of deep reservoirs which become stratified, namely:

1, The amount of free carbonic acid in the water increases during the time when the oxygen is being exhausted through the action of bacteria upon the organic matter. This increase in free carbonic acid facilitates the solvent action of the water upon lead pipes and in Great Britain seems to have had considerable practical significance with reference to lead poisoning.

2, Odors of decay due to putrefaction of organic matters are found in the water as drawn from the bottom layers. These odors are largely due to compounds containing more or less sulphur and phosphorus. They result from the putrefaction of the organic matter originally present in the bottom and sides of the reservoir and in the water flowing into the reservoir, and also from that resulting from the organisms which either grow in the bottom layers or which reach there by settling down from the upper portions of the reservoir.

3, The appearance of the water is made quite unsightly, due to the marked increase in the amount of organic matter dissolved by the water and to the iron which is extracted from the soil and which in a ferrous condition unites with the organic matter. The color and appearance of such stagnant waters is very high and unsatisfactory, particularly after partial aeration by exposure to the air.

4, In the bottom layers many kinds of organisms are found; but it is chiefly the fungi which grow in large numbers in the stagnant layers. Algae and diatoms when present in the bottom layers appear to arrive there only by settling down from above.

In this country the increase in color in stagnant bottom waters is noticed in practically every instance, and this is true to a greater or less extent of the odors of decay.

Improvement of Water from Stagnant Layers.—After ascertaining that the stripping of the bottom and sides of deep reservoirs, in spite of its benefit for some years, will not permanently enable satisfactory water to be obtained either from the bottom or from the top, especially at times of vertical circulation in the reservoir, it is incumbent to consider the means now available for correcting the unsatisfactory quality of the reservoir water. There are three corrective means, the cost of which should be compared with stripping, as follows: *a*, aeration alone; *b*, filtration alone; *c*, aeration and filtration combined.

Aeration.—This affects the water in a number of ways. It practically saturates the water with oxygen and this is, of course, one of the primary benefits which is availed of in connection with the removal of iron from ground waters. This same feature also comes into prominence in connection with the discolorization of stagnant reservoir water as mentioned beyond.

By means of aeration it is possible to remove a large proportion of the free carbonic acid to which reference has already been made. This serves a useful purpose by eliminating or reducing one of the factors associated with the solvent action of water upon lead. It also has a bearing upon this question of odors due to the growths of organisms by the elimination of one important source of food for them. It is worth noting that more vigorous and prolonged aeration is required to remove carbonic acid than to saturate the water with oxygen.

But the special point emphasized in the report is the elimination of those substances like sulphuretted hydrogen which are present in the stagnant bottom layers of reservoirs and which produce the objectionable tastes and odors in stagnant waters.

Filtration.—So far as Messrs. Hazen and Fuller are aware, stagnant water, directly as drawn from the bottom of deep reservoirs, has never been filtered. Such water, entirely devoid of oxygen, would in some ways resemble sewage, and experiences in the filtration of the latter clearly indicate that stagnant reservoir water could not be satisfactorily filtered except by operating the filters intermittently or by giving the water some preparatory treatment, which treatment it has recently been found can best be aeration.

In Wales and Scotland there are a number of large impounded water supplies where the top water is drawn off and filtered. In the case of the newer works of Liverpool and Birmingham even the top water has shown marked effect of stagnation as regards higher amounts of color, due to vegetable stain united with iron, and the presence of fungus growths. The exposure of these waters to air in open sand filters has led to their apparently satisfactory filtration. Prior to the filtration of the water from these reservoirs at Lake Vyrnwy and at the Elan Valley in Wales, it is passed through a very fine screen; and in the case of the newer works at Elan Valley the Birmingham Corporation completed roughing filters for a preliminary filtration of the water prior to its flowing through a long line of tunnel and aqueduct to a point near the city, where the main sand filters are located. These roughing filters are provided solely to protect the conduit and pipes from fungus growths which would otherwise reduce their carrying capacity. At Vyrnwy it is proposed soon to build some roughing filters for the same purpose.

The British reservoir supplies do not suffer from heavy algæ growths and for this reason it is much more feasible in their works to employ top water than would be the case at the Ashokan reservoir.

Aeration and Filtration.—In the stagnant layer of a deep reservoir fermentations take place, esepcially in summer, which result in the solution of considerable amounts of organic matter and also of iron in the ferrous state. This water can be aerated and filtered, thereby entirely freeing it from objectionable odors of decay, and utilizing the iron to a substantial extent as a coagulant to remove the color and other organic matter in the water, and so produce a water better and more acceptable in every way than could possibly have been obtained by filtration of the same water before stagnation and fermentation. It is only within the past year or so that the practical significance of this proposition has been fully appreciated.

The factors in the production of this condition are, first, an amount of oxidizable organic matter in excess of the dissolved oxygen in the water at the beginning of the season; and second, the presence of a sufficient amount of iron.

There is always enough organic matter present in a reservoir to bring about this condition, except in large and very carefully cleaned reservoirs. It can be assumed that there will be organic matter enough under all ordinary circumstances.

The presence of iron would seem to be somewhat less certain. Generally the incoming water does not carry enough iron to be effective in this way. The soil in the bottom of the reservoir is sure to contain a large amount of iron and the fermentations taking place in it tend to the solution of this iron and to its extraction by the water. This seems to be ordinarily the chief source of iron in the stagnant water.

The iron may, however, come from the suspended matter of the incoming water. In a stream like the Esopus, where the water at times is fairly turbid, and where the turbidity of finely divided clay contains a considerable percentage of iron, this source is important and very likely sufficient.

Top Water in Stripped Reservoirs.—The studies made of stripped reservoirs have been singularly lacking in positive results as to the effect of the stripping on the top waters in them. Some general tendencies are indicated, but even in those cases there are many conflicting individual results, and but few definite conclusions can be drawn.

The most important conclusions reached are as follows:

There are many conditions which affect the growth of organisms producing tastes and odors in reservoirs. Growths are the result of a combination of a number of favorable circumstances. Stripping reservoirs is one of the conditions which tends to influence the growths in a reservoir, but there are other conditions which exert as much influence as stripping, or, even under similar conditions, a much stronger influence.

Generally to produce troublesome growths of organisms it is necessary that the reservoir should be seeded or infected with the organisms; that the temperature of the water should be suitable for this growth; that sufficient food supply for the organisms should be present; and that the water should be sufficiently quiet and free from physical disturbance to allow their development. The absence of any of these necessary conditions will keep the water free from growths, even though the other conditions are favorable.

Methods of Improving Top-Layer Waters.—Aeration is a powerful agent in treating waters suffering from tastes and odors of growth and disintegration. Its effect has been most frequently noted with impounded reservoir waters which are later exposed to air and sunlight in another reservoir before the water is used by consumers. This beneficial effect appears to be accomplished partly by a marked reduction in free carbonic acid which is one of the sources of food for organic growths, and partly by agitating the water so that the living organisms then contained in the water are either killed or prevented from subsequently multiplying.

Aeration of this type of water will also remove tastes and odors of decay present in the water when aerated. It will reduce but not necessarily remove satisfactorily the odors of disintegration and odors of decay resulting from the organisms in the water at the time of aeration.

It should be noted that as in the case of carbonic acid far more vigorous and thorough aeration is required to remove tastes and odors than is necessary to saturate a water with oxygen, and there are, no doubt, some tastes and odors which could not be adequately removed by any practical amount of aeration. The violence of the contact between the air and water seems to be important; and a short, vigorous agitation with air often accomplishes that which indefinite exposure of the surface of still or flowing water to the air fails to accomplish.

Messrs. Hazen and Fuller agree at the present date with the conclusions of the late Prof. William Ripley Nichols, who stated in 1883 that "As far as our present knowledge goes there is nothing that can be done to exterminate the algae from ponds in which they occur." They further agree to his statement that stripping is no guarantee against troubles of the nature discussed in the report.

The stripping of the sides and bottom of a reservoir has a well-defined tendency during the early life of a reservoir to guard against objectionable tastes and odors due to organisms. But this tendency is variable in its effect, depending upon a considerable number of other factors. Its effect may be beneficial for many years.

Natural ponds and lakes having clean bottoms and sides give more trouble from growths of organisms at intervals than was formerly supposed to be the case. This fact is partly associated with questions of seeding the water and partly with the meagerness of available observations.

The food obtained for growths of organisms and sides of reservoirs is only one of various sources of food which will bring about these growths when other conditions are suitable such as seeding, temperature and the requisite degree of quiet.

Ultimately it makes comparatively little difference as to growths of organisms in a reservoir water whether the sides and bottom of the reservoir are stripped or not. This is due to the slow but steady elimination of organic matter from the bottom and sides of unstripped reservoirs by bacterial action, and to the equally slow and steady accumulation of organic matter resulting from growths of organisms in all reservoirs, whether stripped or not, in this climate.

Filtration alone, as was believed some 15 years ago, is not wholly successful in removing bad tastes and odors, but when combined with aeration it affords, according to present information, the only effective and practical means of guarding the consumer constantly against bad tastes and odors in impounded reservoir waters.

Recommendations as to the Ashokan Reservoir.—The conclusions of Messrs. Hazen and Fuller, after careful deliberation upon this matter, in the light of experience now available from various large city water works, lead us to the following recommendations:

1, Clearing and Grubbing.—Cut all trees and bushes close to the ground over the entire area of the sides and bottom.

2, Burning Vegetation.—Burn all grass, weeds and shrubs, and see that this is done shortly before the areas are flooded. In other words, do not allow the water to flood any areas on which extensive growths of weeds have occurred since the original preparation of the area.

3, Preparing the Shores.—Around the shore of the reservoir, to a vertical depth of at least 20 ft. below high water, remove all stumps and, so far as necessary, roots and other matters which might become exposed by continued wave-action; and leave the surface with even slopes, so that the shores will be maintained in a presentable condition when the water is drawn down. It is not necessary to spend a large amount of money in this preparation. The wave-action will tend to clean it and accomplish the desired results, but some extra attention should be given to it with reference to its appearance when exposed, and also to prevent as far as possible the leaving of enclosed shallow areas which might serve as places where the spores of organisms would remain and serve as centers of infection when conditions in the reservoir became favorable.

4, Preparing the Bottom.—After removing all the top vegetation from the swamp areas, which can be done by cutting it off close to the surface and burning, careful examination should be made for places where the surface "crust" is so loosely attached to underlying soft material that it might rise after the reservoir is full.

5, Each Basin to Have Outlet.—The separation of the reservoir into two parts, with outlets so that water may be drawn from either or both basins into the aqueduct, seems advantageous.

6, Draw at Any Level.—It is recommended that the reservoir outlets be arranged so as to permit water to be drawn from any desired depth.

7, Aeration.—Arrangements should be provided to aerate thoroughly all the water passing from the reservoir to the aqueduct, except perhaps at times of extremely low stages of water in the reservoir. This can be accomplished by fountains and basins, or other effective appliances to make available the head of the water in leaving the reservoir for bringing it in contact with air to remove the gases, which produce tastes and odors and which result from putrefaction in the stagnant layer and odors from the growth of organisms in the water; and also the carbonic acid which otherwise might serve as a food for further growths in the Kensico reservoir.

In making the foregoing recommendations Messrs. Hazen and Fuller state that they consider:

First, that the stripping of the Ashokan reservoir in itself will not sufficiently prevent tastes and odors so as to allow water of satisfactory quality to be obtained from it at all times.

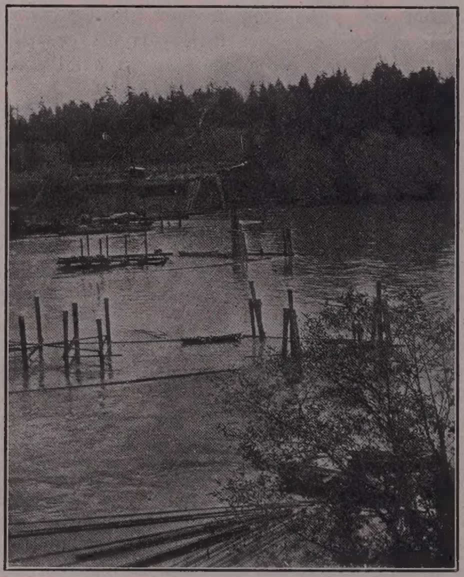
Second, that aeration at a small fraction of the cost will do fully as much in removing tastes and odors as stripping would do in preventing them.

Third, that water of perfectly satisfactory quality can be obtained by aeration and filtration.

Fourth, that this result can be just as certainly and fully accomplished in this way if the Ashokan reservoir is not stripped as if it is stripped.

Protecting Uncompleted Piers During a Flood.

The recent freshets in the Northwest caused by the warm winds melting the mountain snows during the ordinary rainy season caused a great amount of derangement of transportation facilities. Seattle was entirely cut off for over 36 hours, and a number of small towns were more or less under water. The Willamette River, at Portland, rose 26 ft. in 36 hours. Many of the railroad bridges were injured or destroyed, and communication with the South was cut off for a day and a half. Finally temporary communications were made which allowed the Southern Pacific trains to leave Portland from the center of the city on a freight track, making a detour connecting with the main line 5 miles south of Portland.



Protecting Bridge Piers During Floods.

During the time of the freshet, W. S. Barstow & Co., of New York, and Portland, had under construction at Wilsonville for the Oregon Electric Ry. Co. a steel bridge, 1,000 ft. in length and 110 ft. in height. At the time of the freshet the concrete piers were well advanced above the river level. Warned by watchmen, who were patrolling the banks far up the river, that the flood was imminent, the engineers removed all the concrete mixing machinery from the tops of the piers, and the piers were carefully capped over. Around each pier was constructed a powerful log boom, held in place by heavy piling. Inside each boom were stationed men in boats with long pike poles to prevent the rapidly descending drift from tearing away the booms. Three hours after the completion of the last boom the river began to rise, and soon there was 20 ft. of water over the pier foundations. At night the scene was illumined by acetylene head lights, placed on both banks of the river, and the illumination thus given was so bright that the men on duty in the boats had no difficulty in turning aside the dangerous drift that swept down the river.

Owing to these precautions absolutely no damage was sustained by the work, in spite of the fact that all along the course of the river great destruction was wrought to the property of many railroads and plants. As the river is now subsiding it will soon be safe to replace the concrete machinery on top of the piers and continue the work.

Stream-Pollution by Acid-Iron Wastes at Shelby, Ohio.

At Shelby, Ohio, there is a large metal-working industry which for a number of years discharged its wastes into a water-course passing through the city and later into the city sewers. These wastes are acid-iron liquors derived from the pickling process of cleaning iron surfaces. The discharge of these wastes finally gave rise to lawsuits and complaints to the Ohio State Board of Health. This led to an investigation made under a co-operative agreement by the U. S. Geological Survey and the Ohio State Board of Health, from an account of which by Mr. Herman Stabler, published by the U. S. Geological Survey, these notes have been taken.

For some time the waste was discharged by way of a small brook, into Black Fork, a stream with a dry-weather flow of perhaps 1 to 3 cu. ft. per second. The stream was given a very unpleasant appearance by reason of its red discoloration and the water was said to be harmful to stock and was certainly less suitable for domestic and boiler purposes. The city therefore allowed the acid-wastes to be diverted into the sewerage system and thus transferred the principal point of pollution to the outlet of the sewage disposal plant which occupies a 25-acre tract about 3 miles north of the city.

An 18-in. sewer from the city acts as a gravity conduit for the sewage, which amounts to from 250,000 to 300,000 gal. per day, varying with the amount of ground water that enters the system. The sewage first enters a sludge basin for the removal of the larger suspended matter, a wire screen of ½-in. mesh being placed over the exit. There are two of these basins which are used alternately. Each is of brick, 10x24 ft. in plan and 6 ft. deep, and contains about 8,000 gal. From the sludge basin the sewage passes through two shallow reservoirs arranged in series and holding together about five days' flow. From the reservoirs the sewage flows to the two filter beds and is distributed by half-tile carriers. The filters have a total area of 25,000 sq. ft. and were made by laying 6-in. underdrains 20 ft. apart in depressions, covering each drain with a 6-in. layer of gravel 6 to 8 ft. wide, and placing over the whole area 18 in. of cinders averaging ¼ in. in diameter. The underdrains led to an 18-in. outfall sewer which discharges, a few yards away, into Black Fork, a small stream. The filters are used only during the warm months and receive no attention except an occasional weeding. A by-pass provides for the discharge of raw sewage into the outfall sewer and gates lead from each reservoir to the stream. The whole plant is subject to occasional overflow by high water from Black Fork.

An examination of the raw sewage at the disposal plant in 1901, before the acid-iron wastes had been admitted to the sewers, showed it to be considerably diluted owing to ground water which entered the long outfall sewer. Nitrates and nitrites were present, indicating that a supply of oxygen was probably available and, together with a relatively high amount of free ammonia, implying about the stage of putrefaction in the sewers that would be expected in the three hours required for the sewage to reach the disposal plant. At this time the sewage passed directly through the sludge basin, in one-half to three-quarters of an hour, and into the filter beds. The entire plant showed a good percentage of reduction and the effluent, though apparently somewhat putrescible, was not chemically a poor one and could not be regarded as a serious source of pollution to the stream. After the construction of the sedimentation reservoirs the sewage flowing to the beds was in much better condition but the effluent was poorer than before owing to the deterioration of the filters due to neglect.

The tests made after the wastes had been discharged into the sewers for several months showed a sewage in which the acid-iron conditions were extreme. Iron was present in large quantity and the acidity was very high, probably sufficient to prevent bacterial action. The solids were high, over 7,000 parts per 1,000,000, and the loss on ignition was about 1,800. The diminution in acidity was surprisingly rapid and from a sanitary standpoint the effluent was good. The little free acid it contained was not, according to Mr. Stabler, an objectionable addition to the highly alkaline waters of Black Fork but the high oxygen-absorbing power would tend to produce conditions unsuitable for fish life and the extreme amount of iron rendered the stream very unsightly in appearance and its water unfit for domestic use.

In 1904 the company responsible for the acid-iron pollution installed a plant for the recovery of copperas from its spent pickle with the two-fold idea of preventing the pollution and adding to the economy of pickling operations. The spent pickle is drained by gravity into a lead-lined wooden storage tank of rectangular cross-section, having a capacity of about 6,000 gallons, sufficient to accommodate the liquids from four days' work. From the storage tank the liquor is drawn by charges into an evaporator for concentration. The evaporator is a wooden tub of rectangular plan and trapezoidal elevation having a capacity of a little more than 2,000 gal. It is lined with one-eighth inch lead, heated by a steam coil, and provided with a wooden hood and a draft for carrying off the vapor. Iron or steel turnings are introduced into the evaporator to neutralize the free acid and to reduce ferric to ferrous sulphate. The liquor is concentrated to about 45° Baumé and then drawn off into six wooden crystallization tubs. These are rectangular in cross-section and have a capacity of about 675 gal. each. To assist in the crystallization and to provide a support for the crystals, wooden strips are hung in the tubs. The dependent crystals are gathered, drained and barreled for shipping. The mother liquor, together with the more impure crystalline copperas from the sides and bottom of the tubs, is pumped back by hand to the storage tank or the evaporator. Occasionally such matter is discharged into the stream with wash water from the tubs to dispose of accumulated impurities.

The operation of this plant resulted in the recovery of 20 to 25 per cent. of the acid, and the reduction of the objectionable effect of the sewage upon the disposal plant by about 60 per cent., thus greatly lessening the pollution of Black Fork. While not arranged to the best possible advantage it nevertheless proved a profitable investment for the company.

Further examinations after the installation of the copperas plant showed still a strong acid-iron sewage, with a moderate content of organic matter and a very low bacterial content, probably one-fourth that of a purely domestic sewage of the same concentration. When visited by Mr. Stabler in February, 1905, the filter beds were not in use and on a second visit in July of the same year they were being flooded. They showed evidences of being badly clogged, the sewage standing over them to a depth of 18 in. Only about half the sewage passes through the beds, the remainder escaping to the stream by infiltration through the banks or directly through the leaky waste gates of the reservoirs. A superabundance of iron oxide was apparent about the plant, the filtering material and the banks of beds and reservoirs being heavily coated with it. The effluent was clear, almost odorless, and free from suspended matter, but upon standing became turbid and received a reddish cast from precipitation of iron. In short the conditions indicated that the disposal plant had been allowed to deteriorate greatly. The filters had but little part in the purification; their chief effect being apparently a reduction in acidity and oxygen-absorbing power. The plant accomplished an organic purification of about 60 per cent. and a reduction in mineral matter between 35 and 40 per cent.

In the conclusions drawn from this investigation Mr. Stabler notes, among others, the following points: 1, Stream pollution by acid-iron wastes has been taking place at Shelby for about fifteen years to the annoyance of riparian residents below the city for 12 miles. 2. Conditions along Black Fork were greatly bettered by the passage of the waste through the city sewage-purification works, diluted ten to twenty times by weak domestic sewage. 3. The effect of the acid-iron sewage on the purification plant was to fill the basin and reservoirs rapidly and thus decrease their efficiency, to destroy the value of the filter beds in a short time, and to increase greatly the care requisite for the proper maintenance of the plant. Bacterial action was seriously interfered with, the action of the plant on organic matter was diminished, and the effluent was rendered obnoxious by a high content of iron sulphate. Odors about the plant and danger from pathogenic bacteria in the effluent were decreased by the acid-iron character of the sewage. 4. The treatment of pickling waste in a plant for the production of crystal copperas, one-fifth of the acid used being so recovered, reduces the objectionable features of the sewage by about 60 per cent., and is therefore of great value as a means of preventing stream pollution. The copperas-recovery process, the best method known for treatment of sulphuric acid pickling liquors, is attended with a large per cent. of profit, and with a properly arranged plant will entirely obviate stream pollution by waste pickle. 5. Rinse water from the pickling process can, in general, be discharged into the sewerage system of a town or into a stream without detrimental consequences, but it will produce a discoloration of the water unless the dilution is very great. Such waste may be rendered entirely unobjectionable at a trifling cost by precipitation with lime or ammonia.

A RIVER POLLUTION SUIT of an unusual nature has recently been decided by the New Jersey Court of Chancery, 64 Atl. Rep. 746. The facts are indicated sufficiently in the following summary of the decision. Where the operators of a paper mill located beside a canal, from which they drew water under the terms of a deed, had for years discharged refuse fiber and lime into the canal without interfering with the operation of the latter, and the canal owners stood by while large sums were spent on repairing and enlarging the mill, without objecting to the discharge of the refuse into the canal, they were estopped afterwards to object to the discharge of a much smaller quantity of such refuse than had previously been run into the canal. A woolen company, which derived its water for dyeing from the river after the canal had discharged the refuse fiber and lime above mentioned into it, must regard as the proximate cause of its injury by this refuse the act of the canal owners in unnecessarily discharging the water from the canal into the river, and not the act of the paper mill in turning its refuse into the canal.

Letters to the Editor.

EXPANSION JOINTS IN CONCRETE.

SIR: In regard to the use of joints in concrete walls, which Mr. Foster's letter in your number of Dec. 22 discusses, it may be of interest to some of your readers to know that this subject received considerable attention at the 1904 convention of the American Railway Engineering and Maintenance of Way Association. In the report of the Committee on Masonry it was suggested that specifications for concrete should contain the following clause: "In exposed work expansion joints may be provided at intervals of 50 to 100 ft., or as the engineer may direct. A temporary vertical form or partition of plank shall be set up and the section behind it completed as though it were the end of the structure. The partition will be removed when the next section is begun and the new concrete placed against the old without mortar flushing. Locks shall be provided if directed or called for by the plans. In reinforced concrete the length of these sections may be materially increased at the option of the engineer."

In the discussion of this clause, Mr. C. S. Churchill, chief engineer of the Norfolk & Western R. R., suggested that it might be well to specify the maximum length of wall in which no joint is required. The rule of his department was to make the maximum length of an arch or retaining wall without an expansion joint 90 ft. In other words, if the length of the arch or retaining wall was 95 ft. he would place the joint at the center. He believed in having a joint about every 45 ft. in a wall. On his road an arch without expansion joints was built under a 70-ft. bank about two years before; expansion cracks formed vertically in the side walls, running up through the arch, and while they were not all serious they showed the advisability of such a rule as he mentioned.

Mr. Charles M. Mills, of the Philadelphia Rapid Transit Co., said that in some cases he found it desirable to provide for considerable movement in walls by the use of steel bars, so placed in the forms as to make a sliding latch, to maintain the alignment of the walls in case of any tendency of one section to move out under pressure past the adjoining section. In some cases he had made a joint by finishing up against the end forms, so that the concrete in the succeeding section would be deposited against the hardened surface of the last section, as contemplated in the proposed specification.

Mr. J. W. Schaub, a member of the Committee on Masonry, mentioned an experience with the foundation walls of a building about 550 ft. long, which were exposed for several days after removing the forms until a fill could be placed about them. It was found that a crack appeared about every 50 ft., always along lines of least resistance. Mr. Schaub did not believe these cracks were due to temperature changes, however, but attributed them to a shrinkage of the concrete on exposure to the air. His plan of construction was to provide a joint every 50 ft. or so by making the end of each section of the wall serve as part of the form for the next section.

The Galveston concrete sea wall, described at length in the Record of July 4, 1903, was cited by Mr. H. W. Parkhurst as showing some instructive effects of temperature changes. The blocks were made in alternate sections about 50 ft. long, dovetailed together. The temperature was about 32° when he was there, so that the contraction was probably as much as it would ever be in that place. Most of the joints seemed to adhere, but at irregular intervals there was one open, possibly as much as ⅝ in. or even more. The wall rests on firm piles and is very heavy and uniform, so that the irregularity in the appearance of the cracks could hardly be explained. Mr. Parkhurst was convinced from his examination of the wall that expansion joints should be used at frequent intervals, particularly if the work is built in warm weather.

Mr. H. G. Kelley mentioned an experience which convinced him of the importance of joints in concrete work exposed to great temperature changes. He placed contracts for a brick roundhouse, but labor troubles prevented the use of brickworkk and the structure was accordingly redesigned for hollow concrete block walls and solid concrete pilasters, no allowance being made for contraction. The building was constructed in the summer. When the temperature fell far below zero in the winter, the round house being unheated at the time, slight cracks appeared in the rear panels, following the line of least resistance above and below the window openings. The distance between pilasters was about 26 ft. and the cracks opened a maximum of 1/16 in. With the heating of the round house and the advent of warmer weather, the cracks entirely disappeared.

After these and other statements regarding expansion had been made, the wording of the clause above quoted was debated, and Mr. C. F. Loweth pointed out that it was not right to insist that a joint should be placed every 50 ft., for there were some structures of great thickness and moderate exposure in which a joint every 100 ft. would be ample. After considerable discussion the first sentence was amended to read: "In exposed work expansion joints may be provided at intervals of 30 to 100 ft., as the character of the structure may require."

Very truly yours,
Chicago, Dec. 26. James Gray.

Sir: Mr. W. H. Foster in your issue of Dec. 22 puts some pertinent questions on this subject and I venture to submit for consideration what I suppose may be styled heterodox ideas thereon. I consider that all concrete work should be monolithic; it goes without speaking that there are to be good materials, good design, good workmanship, and rigid supervision. If concrete work be built up under these conditions we will get as near to indestructibility or permanence as is humanly possible.

We overcome the expansion of steam which is of far greater power than that of frost by increasing the strength of the boiler plate, and that is just what has to be done in concrete work. Suppose a wall be built under the conditions just premised—if reinforced so much the better—with its joints bonded properly, then we have a monolith which like Captain Cuttle's watch, "will give satisfaction."

An expansion joint is an invitation for atmospheric action, rain water and frost to penetrate the work, attacking a much larger area than if there were no such opening, and the expansion joint soon becomes an expanded joint continually increasing in size. The wall will probably make its own joints where they are needed, not at the points where they have been arranged for, so now there will be two sets of joints. I propose to have no artificial fissures and when cracks big or little show themselves then after a little while fill them up with "annealed cement," which will make the wall stronger than before, and we still have our monolith. The giant monoliths of Stonehenge and of Brittany would hardly have kept their form for over 2,000 years in a very changeable climate if they had been built on the expansion joint system. I believe the National Capitol is built on monolithic lines. If there is any virtue in expansion joints the more loose stones there are in its walls the better. One thing I am sure of, that a comparatively even-faced natural cliff of any length will endure much longer than a similar one provided with natural expansion joints and fissures.

As to the action of wave force on marine work I am not without personal experience. Under powerful pressure caused by the sweep of the sea during an unusually severe storm large unbonded blocks will be thrown out of place on a pier or exposed sea wall like so many pebbles, but if efficiently bound together (the boiler plate illustration again) small blocks cannot be, and are not, moved.

Yours truly,
Baltimore, Dec. 24. H. J. Livingston.

Taxing Power Companies in the West.

Sir: Allow me to call the attention of your readers to a wholly unjust proceeding on the part of the executive officials in Washington regarding power development in forest reservations in the West. I have just read your editorial of to-day on water powers, and think you should add to your perfectly true statements regarding the value of water powers some criticism of the proposal of the Interior Department to levy a tax which will make those same powers of little or no value. You people living here in the East, handy to Washington, can go down there and get any little mill brook, not big enough to water a good bunch of steers, improved under some river and harbor bill. Out in God's country, on the other hand, we are not so near the seat of government, and there are not so many of us to help along a good cause, and so when we ask Congress to do as much for us along the headwaters of the rivers as she does for those living lower down, we get nothing but an invitation to pay for the proposed improvements. Any measly coast town can get money from the government to improve its little spittoon of a harbor, but has anybody heard of any free irrigation work? The nearest to the latter is the scheme of the Reclamation Service, which is about as free as a hand organ monkey.

It naturally makes those of us who have been able to see the value of water powers, and have raised money to develop them, almighty disgusted to find that our plans must be given up because the Roosevelt administration considers the companies utilizing powers in the forest reserves should be taxed heavily according to electricity supplied rather than benefits derived. I am heartily in sympathy with establishing forest reserves, particularly in view of the oft-repeated statements by forestry experts that these tracts will be self-supporting. But I don't see why the valuable water powers in these reservations should be made as worthless as a plugged quarter by a system of taxation that is not on speaking terms with justice. A few years ago we all voted with a whoop for a fair deal, and now many of us find we are up against a brace game for sure. Of course these people in the department think they are acting fairly and squarely; nobody believes otherwise so far as I know, but the trouble is that they do not appreciate the importance of these mountain streams they are rendering useless by their proposed taxation, and treat them like so much timber or so many acres of land. They do not see that the investment needed to develop the powers is an enormous one in proportion to the investment for other business conducted in the reservations, and the money simply cannot be raised if the proposed scheme of taxation is carried out. It is dead wrong to bottle up natural resources in that way.

Very truly yours,
New York, Dec. 29. Westerner.

Centrifugal Force on Curves.

Sir: On page 674 of your issue of Dec. 15 you state in an article with sarcasm the peculiar action of centrifugal force in a railroad accident. I do not think the sarcasm is justified for the reason that evidently centrifugal force was not the cause of the accident. If the car was a double-truck car with a long rear overhang it is quite probable that the accident was caused when the forward truck entered the curve. This would cause the rear platform of the car to swing outward, which carries with it a horizontal force acting at the feet, which would throw the upper part of the body towards the inside of the curve. The force of this power would of course be in proportion to the speed of the car when rounding the curve. This could very easily explain the cause of the accident.

Yours truly,
New York, Dec. 24. F. W. Schwiers.

An Unusual Fire Test of Portland Cement.

Sir: A very interesting test as to the use of Portland cement as a fire-proofing material has been obtained recently at the works of the Vancouver Portland Cement Co. at Tod Inlet, British Columbia. About six weeks ago one of the rotary kilns in which the raw materials used in the manufacture of cement are calcined had to be shut down for relining. These kilns are lined inside with fire brick of the best quality high in alumina in order to stand the intense heat maintained.

At the time the kiln had to be shut down, the company were out of the special brick required for lining their kilns and being forced to have the kiln running as soon as possible a good common Scotch 9-in. fire brick was used for the purpose, and for a trial the men in charge of the lining of the kiln used neat Portland cement for patching and for mortar, putting also a layer about 1 in. thick between the iron shell of the kiln and the brick and also between the joints. After finishing the kiln was immediately started again and run for about five weeks continuously, when it had to be shut down again, owing to a hot spot developing visible on the outside of the shell. After cooling the kiln it was found that the fire brick put in five weeks ago had almost melted away, while the cement patch and cement lining were in perfect condition, solid, hard as a rock and not cracked or crumbled; in fact some pieces had to be taken out with a pick axe.

This is remarkable considering the intense heat kept in the kiln continuously, from 2,000° to 2,300° Fahrenheit. The above test not only gives a proof of the usefulness of Portland cement as a fire-proofing material, but it also speaks well for the qualities of Vancouver brand of cement.

Yours truly,
Vancouver, Dec. 18. Adolph Neu.

Sewage Purification Data for Providence, R. I., during 1905, are summarized in the report of City Engineer Clapp for that year. The works were described in The Engineering Record of Aug. 13, 1904. The population served by the sanitary sewers of the combined system is 178,000. The sewage is a combination of manufacturing, wool washing, jewelers, dyeing and bleaching wastes and domestic sewage, and its strength in parts per 100,000 is, albumenoid ammonia, total, 0.741; suspended, 0.358; chlorine, 60.59. The maximum daily flow in million gallons was 55.4, the minimum was 8.3, and the average amounted to 22.707. The average daily flow of sewage treated was 22,097,000 gal. The settling basin holds 11,130,000 gal. In treating the sewage, 599 lb. of lime and 515 lb. of copperas were used per million gallons. In terms of albumenoid ammonia the percentage of organic matter removed from the sewage was: total, 48.20; suspended, 86.44. The sludge amounted to 3,040 gal. per million gallons treated. This was pressed and cakes hauled by train to a dump ⅛ mile away. An average of 67,189 gal. of sludge was pumped per day, and produced 85.7 tons of sludge cake, the solids being 7.89 per cent. of the wet sludge. In the cakes the percentage of solids was 26, so that really 22.3 tons of solids were extracted, the presses averaging 7.13 hours per day. The lime added per thousand gallons of sludge was 24.87 lb. The operation of the plant cost, for chemical precipitation $313 per million gallons, and for sludge disposal $2.66.